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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are FOUR dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues TWENTY dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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New England Water Works Association.

ORGANIZED 1882.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE NEW TEN-MILLION-GALLON RESERVOIR OF THE CITY OF DAYTON, OHIO.

BY LEONARD METCALF AND WILLIAM T. BARNES.*

In the year 1917–1918 the Water Department of Dayton, Ohio, built a covered concrete masonry reservoir of 10 million gallons capacity. The population, then estimated at 148 000, — which had practically doubled in twenty years and increased by 38 per cent. in the last decade, — reflected growing war activities. The water consumption was 50 per cent. greater than ten years earlier and the rapidly increasing demand threatened to outstrip the available resources of the department, so that it was necessary to improve the plant, notwithstanding the abnormal prices then prevailing.

Though the average consumption was but 13 million gallons daily, the ordinary maximum daily rate of consumption was upwards of 18 million gallons, and the ordinary maximum hourly rate was equivalent to 30 million gallons daily. The ratio between the maximum and the minimum hourly fluctuations was approximately as 5 : 1, the minimum rate of consumption being about 6 million gallons per day.

The water supply is derived from a system of driven wells on the banks of the Mad River, in proximity to the industrial center of the city, and is pumped to the consumer under direct pressure, except in the high service district of the northwest, where there is a standpipe of 900 000 gal. capacity.

* Both of the firm of Metcalf & Eddy, Boston, Mass.

With such wide variations in rate of consumption and with no low service storage, the conditions were difficult to meet, for the entire maximum demand had to be supplied directly by the pumps and the wells, the normal capacity of which was less than the actual maximum rate of consumption during periods of more than one hour. This condition was further aggravated, during fires, by the fire-stream demand and the greater consumption, waste and leakage of water resulting from raising the pressure at such times. The effect upon consumption of this increase in pressure is interestingly shown in Table 1 and Fig. 1.

These conditions involved, in various ways, elements of hazard which it was not wise for the city to assume, particularly in view of its important war work. The possible direct loss from fire, and the indirect losses from interruption of service and in output and wages following a severe fire, were too serious to be incurred.

TABLE 1.

TEST OF RELATIVE WATER CONSUMPTION UNDER VARYING CONDITIONS.

Test made March 3, 1917, with DeLaval 20 M.g.d. unit in service.
Rate of consumption determined from Venturi Meter Chart.

Time Period. March 3, 1917, P.M.	Pump Pressure, Pounds.	Rate of Consumption in M.g.d.			
		During Period.	Change by Increasing or Decreasing Pressure.	Increase above Average Consumption with Pressure at 60 Lt. (Average =12.6 M.g.d.).	
				M.g.d.	Per Cent.
3.15 to 3.40	60	13.1	.....	...	....
3.42 to 3.53	90	16.0*	+2.9 −3.2	3.4	27.0
3.54 to 4.05	60	12.8†	.....	...	....
4.06 to 4.12	80	14.75	+1.95 −2.15	2.15	17.0
4.12 to 4.22	60	12.6	.....	...	....
4.22 to 4.31	70	13.7	+1.1 −1.7	1.1	8.8
4.31 to 4.42	60	12.0	.....	...	....

* In first three minutes increased to 18.2 M.g.d.

† In first six minutes fluctuated between 11.5 and 12.8 M.g.d.

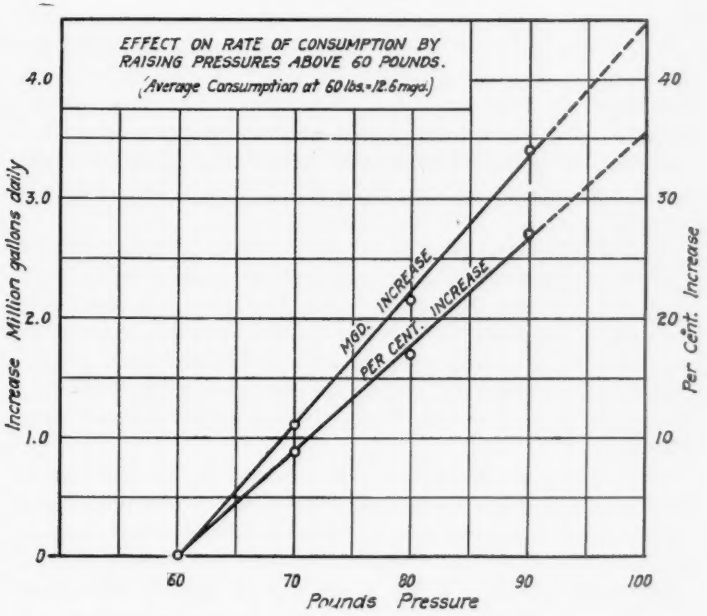


FIG. 1.

Influence of Topography upon Character of Water Works Plant. — The topography of Dayton lends itself admirably to the division of the water distribution system into two services, — high and low. The low service comprises the congested value district and surrounding business district of the city, upon the floor of the broad valley through which flows the Miami River and its main tributary, the Mad River, and into which discharge the Stillwater River and Wolf Creek. Above the river plain, which lies at general elevation of 740 ft. (above mean sea level), and virtually surrounding the city, lie upland plains, the margins of which are generally between elevations 850 and 900, and which rise with increasing distance from the city, to an elevation of 1 000 ft., more or less. The upland plains furnish advantageous sites for reservoirs close to the heart of the city, from which water may

be delivered to the low service district at fair domestic pressure (70 lb. per sq. in., more or less) in ample volume for the maximum fire demand, without undue friction loss, and without involving burdensomely expensive pipe connections. The high service districts upon the hillsides and heights above can most advantageously be served from interconnected standpipes, to which water may be pumped from the centrally located main pumping station.

Consideration was given to the possibility of building a suction reservoir in proximity to the pumping station, and it seems likely that such will be built at a later date; but as the first step in the solution of the storage problem it was found more advantageous to locate the equalizing reservoir upon the upland plain. Later, additional reservoirs will be added upon the heights in different sections of the city, feeding their supplies into the common center, the heart of the city.

Function of the Reservoir. — The function of the reservoir is, of course, to furnish storage and equalize the rate of pumping so that, regardless of fluctuation in domestic and industrial consumption and of ordinary fire demand, water can be delivered into the distribution system in a way to develop the greatest safety and economy in the operation of the pumps. In view of the high cost of labor and building material, it was desirable that the changes involved should be kept at a minimum.

The significant rates of demand for water were found to be:

Year.	Population.	Slip. Per Cent.	Rate of Water Consumption.				
			Per Capita.	Average Day.	Maximum Day.	Maximum Week.	Maximum Hour.
			Gal. per Day.	M.g.d.	M.g.d.	M.g.d.	M.g.d.
1911	120 000	8	73	8.7	....	....	..
1912	124 000	10	76	9.5	13.0	....	..
1913	127 000	15	85	10.7	16.5	....	..
1914	130 000	9	86	11.2	15.1	14.3	25
1915	132 000	6	75	9.9	12.3	....	..
1916	145 000	6	84	12.1	18.3	16.5	32*
1917	152 000	6	86	13.0	17.5	....	..
1918	160 000	5	88	14.2	20.4	....	..

* Actual.

The maximum rates of demand which had occurred up to 1917 were as follows:

		Ratio to Av. Daily for Yr. (12.13 M.g.d.).
July 24–30, 1916.	Maximum weekly rate = 16.5 M.g.d.	136%
July 24, 1916.	Maximum daily rate = 18.3 M.g.d.	156%
July 30, 1916.	Maximum hourly rate = 31.9 M.g.d.	263%
July 24–27, 1916.	Maximum for four consecutive days = 16.71 M.g.d.	138%

SIGNIFICANT RATES OF CONSUMPTION, 1916.

Hour Ended.	Monday, July 24.	Tuesday, July 25.	Wednesday, July 26.	Thursday, July 27.	Friday, July 28.	Saturday, July 29.	Sunday, July 30.
			Minimum Rates.				
1 A.M.	8.40	9.32	9.00	8.24	8.62	8.02	8.82
2 A.M.	7.82	*7.04*	7.94	8.00	*7.04*	9.17	7.97
3 A.M.	*7.42*	8.12	*7.82*	8.06	8.42	8.10	*6.70*
4 A.M.	7.67	7.92	8.24	7.56	8.50	7.82	7.06
			Maximum Rates.				
6 P.M.	26.22	22.06	24.48	25.82	25.14	25.13	23.27
7 P.M.	29.51	*24.11*	*27.98*	*28.48*	*28.86*	*28.69*	*31.92*
8 P.M.	*29.69*	21.36	27.12	25.86	28.08	24.96	18.00
9 P.M.	19.81	15.30	17.06	20.34	18.12	16.54	14.43
Average Daily M.g.d.	*18.3*	16.0	16.8	16.6	16.8	16.6	14.9

Average for week (shown above) *16.5* M.g.d. (maximum weekly in year 1916).

(Note that the maximum rates for less than one hour were substantially greater than the rates here shown.)

Capacity of Reservoir, 10 000 000 Gallons. — Under normal conditions the capacity of the proposed reservoir would have been fixed at 25 to 30 million gallons, but in view of the conditions in the building market, induced by the war, it was felt necessary to

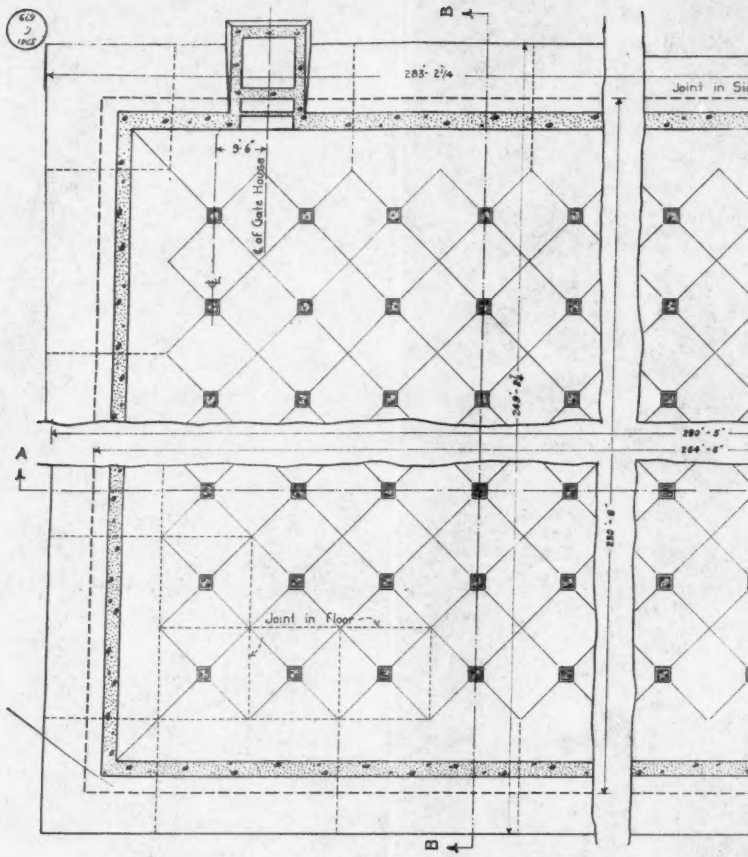
reduce this limit. The capacity adopted was determined by the amount of storage necessary to equalize the hourly fluctuation in domestic and industrial water consumption, provide storage which would facilitate the making of minor repairs at the Keowee Street pumping station, and meet the "1916 standard" fire supply requirements of the National Board of Fire Underwriters.

A study of the hourly fluctuation in demand indicated that during the period of heaviest consumption recorded (from July 1 to July 31, 1916) the storage capacity necessary to equalize the hourly demand was approximately 3 million gallons, the maximum and minimum requirements during this period being 3.3 and 1.2 million gallons, the average throughout the month 2.2 million gallons, or approximately 15 per cent. of the actual average daily consumption of 14.7 million gallons in the month of maximum demand, July, and 24.8 per cent. of the mean daily consumption for the entire year. To maintain a ten-hour flow of the maximum fire demand as prescribed by the 1916 standard of the National Board of Fire Underwriters required an additional storage capacity of approximately 7 million gallons. The sum of these amounts, aggregating 10 million gallons, was therefore adopted as the necessary storage capacity for the new reservoir.

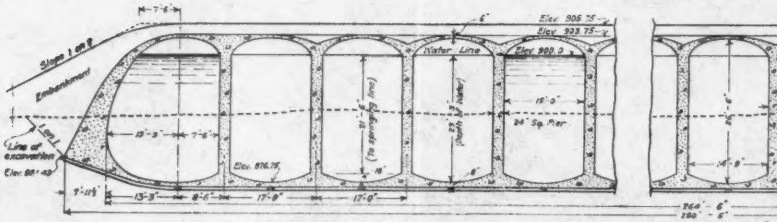
Design.

After preliminary studies, designs were prepared for a groined arch type of structure, as on the whole the most desirable and probably the cheapest type for this service, to be built of concrete 264.5 ft. long, 230.5 ft. wide, and 26.5 ft. deep in internal dimensions, and with a $23\frac{1}{4}$ ft. depth to the flow line. A plan and sections of this structure are shown in Plates I, II, and III following.

Although the work was widely advertised and a considerable number of bids were looked for, but three bids were received, — all from local contractors, — and were opened on July 31, 1917. These bids amounted to $164 592, $188 805, and $192 835, exclusive of the materials to be furnished by the city, which were estimated to aggregate the further sum of $33 500. They were all in excess of the engineer's estimate of $131 000, exclusive of materials to be furnished by the city. When it appeared that



SECTIONAL PLAN AT SPRINGING LINE



SECTION ON A-A

PLAN AND SECTION OF GROINE

PLATE I.
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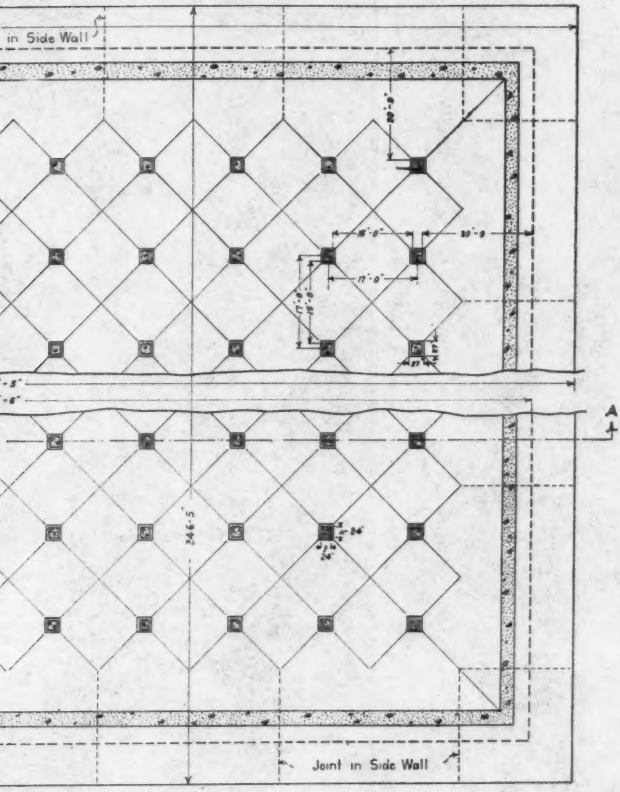
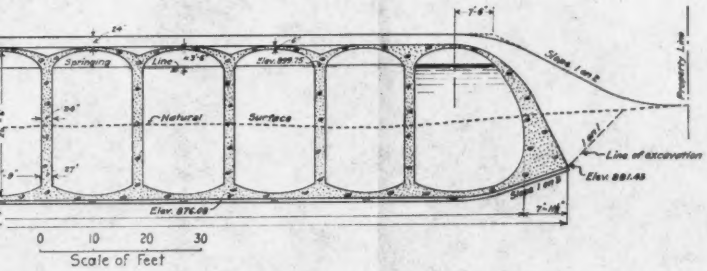
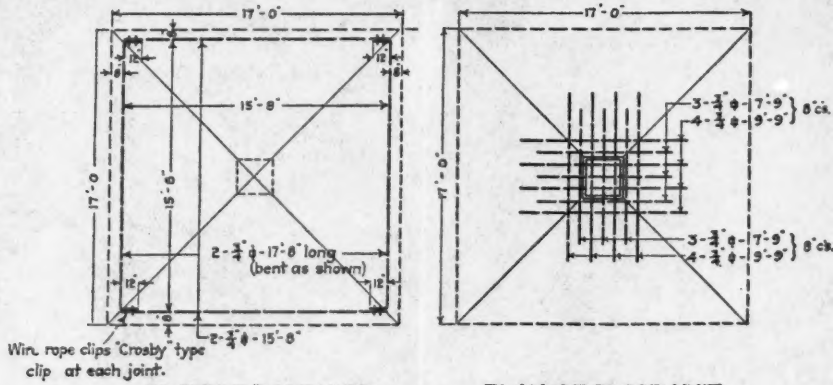
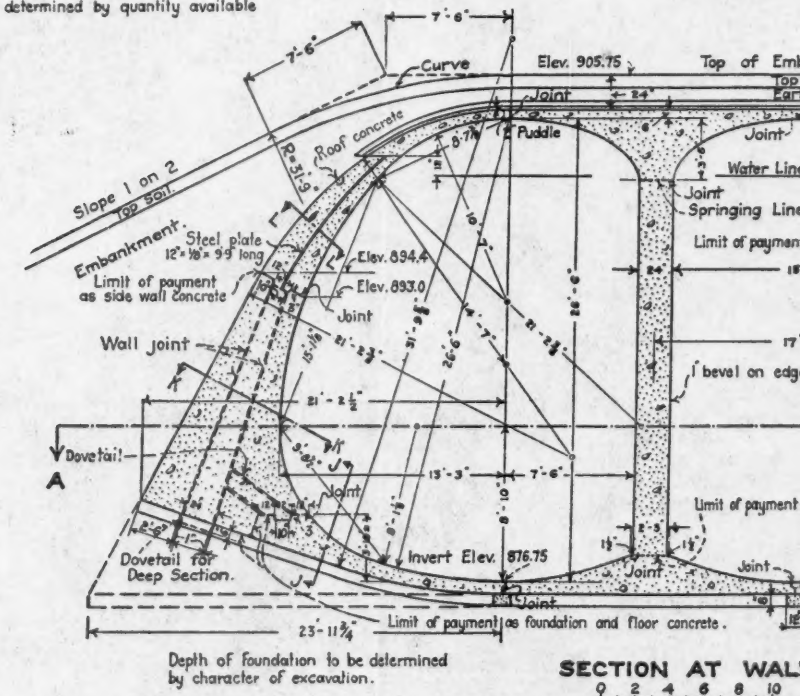


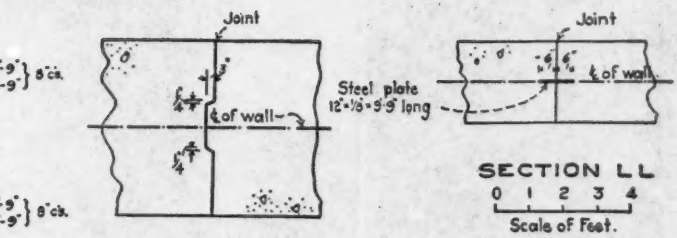
LINE OF ROOF



ROINED ARCH RESERVOIR.


17'-0"
15'-8"
2-¾" ϕ - 17'-8" long (bent as shown)
2-¾" ϕ - 15'-8"
Wire rope clips "Crosby" type clip at each joint.
3-¾" ϕ - 7'-9" } 8" ctrs.
4-¾" ϕ - 9'-9" }
PLAN OF ROOF UNIT
PLAN OF FLOOR UNIT
0 2 4 6 8 10
Scale of Feet.


Thickness of top soil to be determined by quantity available
Slope 1 on 2
Top Soil
Embankment
Roof concrete
Curve
Elev. 905.75
Top of Emb
Joint
Puddle
Water Line
Springing Line
Limit of payment
Steel plate 12"×⅜"×9'9" long
Limit of payment as side wall concrete
Elev. 894.4
Elev. 893.0
Wall joint
bevel on edge
Dovetail
A
Limit of payment
Dovetail for Deep Section.
Invert Elev. 876.75
Limit of payment as foundation and floor concrete.
Depth of foundation to be determined by character of excavation.
SECTION AT WALL
0 2 4 6 8 10
Scale of Feet

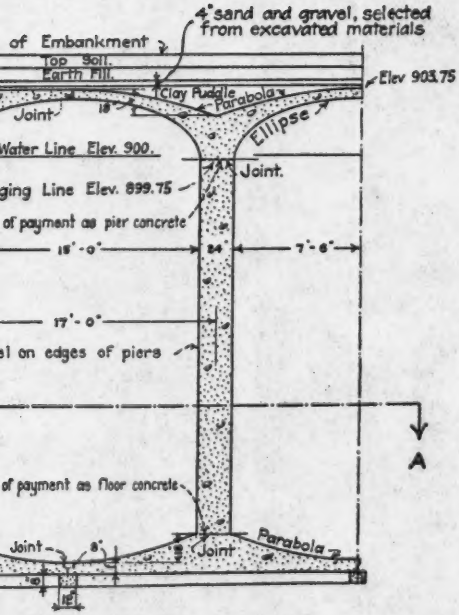


SECTION K K
0 1 2 3 4
Scale of Feet.

SECTION L L
0 1 2 3 4
Scale of Feet.

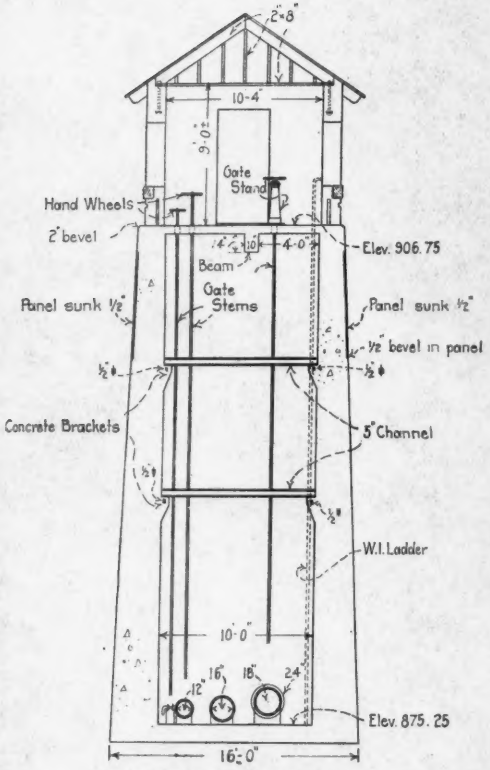
City will furnish Portland cement, steel reinforcing bars, steel plates for expansion joints and certain other metal work.

Sub-floor blocks to be laid first, then floor in alternate units. Joints are to be made ONLY in the manner and at locations as indicated.



WALL.

Concrete, 1 part cement to 6 parts fine and coarse aggregate in floor, piers and roof 1 part to 8 parts aggregate in side walls and gate chamber.



SECTION THROUGH GATE HOUSE AND CHAMBER

Drawn by ... C.W.R.
Traced by ... C.W.R.
Checked by ... G.A.T.

0 2 4 6 8 10
Scale of Feet

PLATE III.
N. E. W. W. ASSOCIATION.
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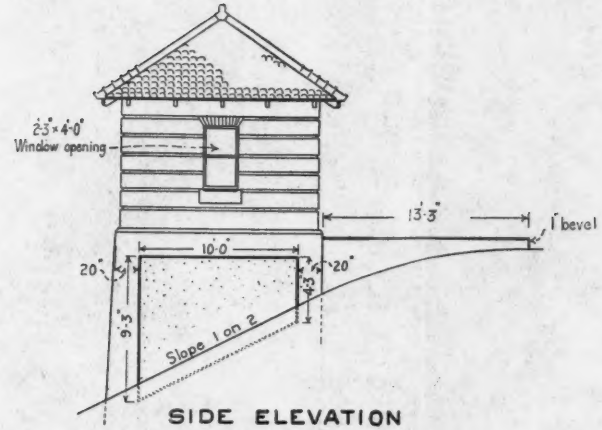
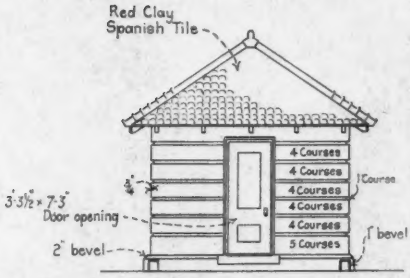
DAYTON, OHIO.



SIDE ELEVATION

0 2 4 6 8 10
Scale of Feet



FRONT ELEVATION

0 2 4 6 8 10
Scale of Feet

GATEHOUSE.

these local contractors were not familiar with groined arch construction, whereas they were experienced in the building of flat-slab roof construction, and were therefore ready to submit more advantageous figures upon a structure of the latter type, the bids were all rejected.

New specifications were prepared, permitting the submission of bids upon the engineers' designs and upon designs of the bidder, subject to the following requirements:

Requirements for Alternate Design.

General.

Section 7.16a. The capacity of the reservoir shall be ten (10) million gallons as computed with high water not higher than elevation 901.0. The depth of water shall not be less than twenty-three feet three inches (23 ft. 3 in.) nor more than twenty-four feet six inches (24 ft. 6 in.). The overall interior dimensions, general arrangement, and gatehouse details and location shall conform in general to the drawings hereto attached.

The quality of materials used, character of construction and other requirements, as contained in the specifications, shall apply to alternate design.

Soil Pressures and Unit Stresses.

Section 7.16b. The reservoir shall be designed to carry a superimposed load on the roof of 265 lb. per square foot, with side earth slopes as shown on the drawings of Metcalf & Eddy hereto attached.

In computing earth loads and pressures a cubic foot of earth shall be assumed to weigh 100 lb. The angle of repose shall be assumed as 30 degrees.

The maximum soil pressure shall not exceed 6 000 lb. per square foot.

The working unit stresses in the concrete and steel shall not exceed the allowable working stresses recommended in the final report of the Joint Committee on Concrete and Reinforced Concrete, 1916, for concrete having an ultimate compressive strength of 2 000 lb. per square inch. The methods of computation used shall in general conform with the methods outlined in said final report of the Joint Committee.

The tensile or compressive stress in the steel shall not exceed 16 000 lb. per square inch.

In calculating moments of resistance the tensile stresses in the concrete shall be neglected.

Outside Wall.

Section 7.16c. The outside wall, if of the arched type, shall conform to the design shown on drawing sheet No. 3 hereto attached,* for the groined arch type of reservoir; if a reinforced concrete or plain concrete type is adopted

* Numbers refer to plans accompanying specifications, all of which are not here reproduced.

the wall shall conform to the requirements herein outlined, subject to the approval of the Director.

The outside wall shall be designed so as to be self-supporting; and the stability and resulting stresses and soil pressures shall be computed on the basis, first, of the reservoir full of water with vertical earth load on wall and roof but no horizontal earth thrust against the wall; and second, of the reservoir empty with vertical earth load on wall and roof and horizontal earth thrust against the wall.

Floor.

Section 7.16d. The floor, if of the groined arch type, shall conform to the design shown on the drawings sheets Nos. 2 and 3 hereto attached; if of the flat type the floor shall be at least 8 in. in thickness and shall be reinforced with ½-in. square bars spaced 12 in. on centers in both directions, or the equivalent thereof, subject to the approval of the Director.

The floor shall be divided into panels or blocks according to the column spacing. The joint between adjoining blocks shall be made and supported as shown by "Details of Floor Joints" drawing sheet No. 3 hereto attached.

Columns.

Section 7.16e. If the roof is of a type other than the groined arch, the columns shall be of concrete reinforced with four vertical bars ¾-in. square, one in each corner, and with hoops ¼-in. round, spaced 12 in. on centers. The vertical bars shall extend at least 18 in. into the footing and into the roof slab. Means shall be provided for uniting the ends of each hoop so as to develop the full strength of the hoop. The column sections shall be 24 in. square, round or octagonal. If the groined arch roof is used the columns shall conform to the drawings shown on sheet No. 3 hereto attached, or the equivalent thereof, subject to the approval of the Director.

Roof.

Section 7.16f. The roof, if of the groined arch type, shall conform to the design shown on the drawings sheets Nos. 1 to 3, inclusive, hereto attached, or the equivalent thereof, subject to the approval of the Director; if of the reinforced, flat-slab type the dimensions of the capitals, drop panels and slabs shall at least be equal to those shown on the drawing sheet No. 7, "Flat-Slab Type — Alternate Design," hereto attached.* The reinforcement of the slabs may be according to the so-called "four-way, two-way, or circumferential system," and shall be designed to conform with the requirements hereinafter stated.

The spacing of the columns shall be not less than 17 ft. nor more than 20 ft. on centers.

Design of Flat-Slab Reinforcement.

Section 7.16g. The design of the steel reinforcement of the flat-slab roof shall conform to the following rules:

---

* See note, page 225.

Let w = total dead and live load on roof = 365 lb. per square foot of roof.
L = span length of slab = distance center to center of columns — $\frac{2}{3}$ diam. of capital if circular, or $\frac{3}{4}$ width of capital if square.
b = slab width = distance center to center of columns.

The effective depth of the slab shall be taken as the distance from the face of the concrete in compression to the center of the tension steel nearest the compression surface in two-way reinforcing, and at mid-span in four-way reinforcing. Over the column in four-way reinforcing the depth to the center of gravity of all the steel cut by the section may be used.

Negative bending moment, in foot-pounds, in the column head sections $= .045wbL^2$; and in the mid-section $= .009wbL^2$.

Positive bending moments in foot-pounds in the outer section $= .0225wbL^2$; and in the inner section $= .0135wbL^2$.

If provision is made by reinforcement, to care for the negative bending moment in the outside walls from the roof slab, the end panels of the roof may be designed on the same basis as interior panels.

The sectional area of all bars crossing any section multiplied by the sine of the angle between the bars and the section under consideration, may be taken as effective at that section.

The point of inflexion shall be taken at a distance from the center line of columns equal to $\frac{1}{4}$ L + $\frac{1}{3}$ diam. of capital if circular, or $\frac{1}{4}$ L + $\frac{3}{8}$ side of capital if square, for slabs having drop panels.

The design shall provide and drawings shall show adequate provision by chairs, or other methods, for securing the reinforcement in place.

If bars are extended beyond the column capitals and are used to take the bending moment on the opposite side of the column, they must extend to the point of inflexion. Bars and diagonal bands used as reinforcement for negative moments shall extend on each side of the line drawn through the column center at right angles to the direction of the band a distance equal to 0.35 of the panel length — that is, the distance center to center of columns, and bars in the diagonal bands used as reinforcement for positive moments, shall extend on each side of the diagonal through the center of the panel a distance equal to 0.35 of the panel length. Bars spliced by lapping and counted as only one bar in tension, shall be lapped not less than 80 diameters if splice is made at point of maximum stress, and not more than 50 per cent. of the rod shall be so spliced at any point in any single band or in any single region of tensile stress. Continuous bars shall not all be bent up at the same point of their length, but the zone in which this bending occurs shall extend 20 diameters on each side of the assumed point of inflexion.

If straight bars only are used in any band, they shall extend 20 diameters beyond the inflexion point.

The maximum spacing of bars shall be not over 16 in. center to center.

The design of the roof reinforcement shall be in all respects satisfactory to the Director.

Proportions for Concrete Masonry.

Section 7.16h. If the outside wall is constructed of the arch type, or if a heavy plain concrete gravity section is used, the concrete in the outside wall and gate chamber may be Class B concrete. If, however, a reinforced concrete type of outside wall is adopted, the entire structure including the outside wall and gate chamber shall be constructed of Class A concrete. The proportions for these two classes of concrete are given in Section 7.5.

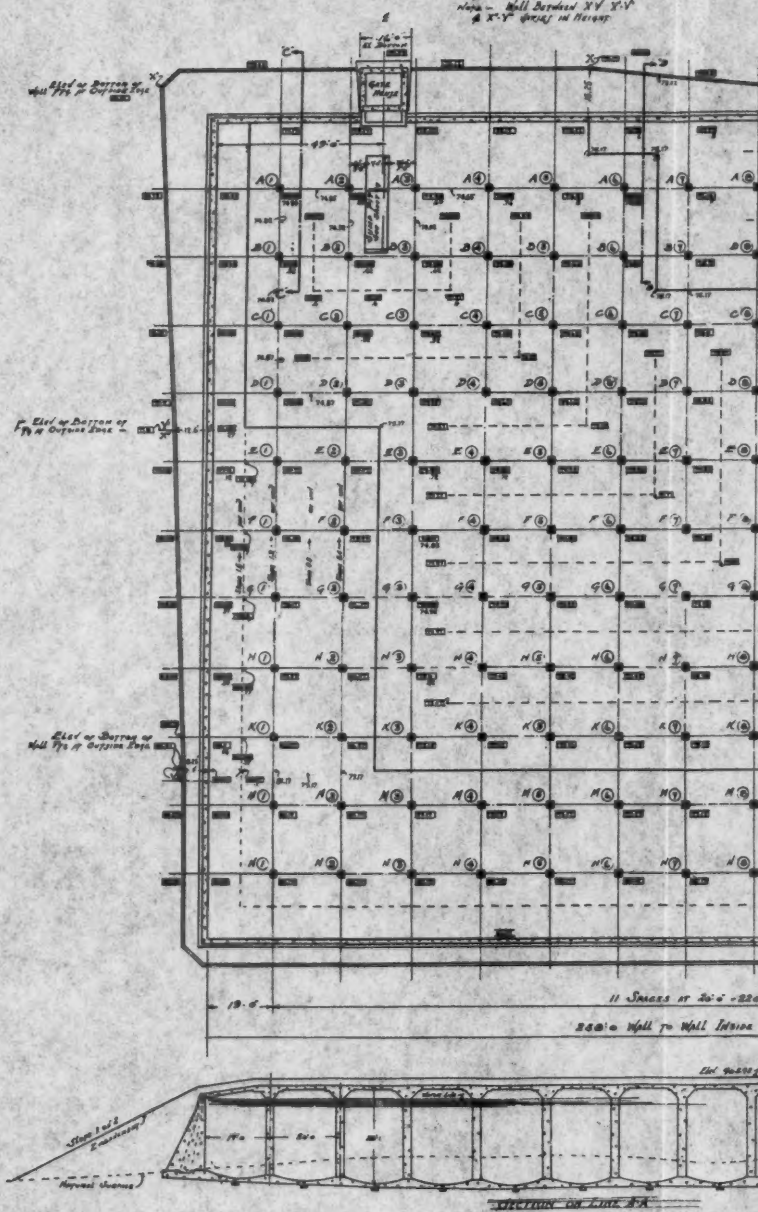
On October 5, 1917, the following bids were received:

	Unit Price Form of Contract.		Cost-Plus-Per-Cent-Profit-or-Fee Type.	
	Excluding Materials furnished by City.	Including Materials furnished by City.	Excluding Materials furnished by City.	Including Materials furnished by City.
Flat-Slab Type.				
Structural Concrete Company	$162 423	$199 660	.....	.....
Danis-Hunt Construction Company	93 000	133 935	$104 500	$134 832
J. I. Geiger & Miami Engineering and Construction Company	99 685	153 613	99 685	153 613*
Groined Arch Type.				
Price Bros. Company	$114 489	$143 310	.....	.....
J. I. Geiger & Miami Engineering and Construction Company	126 837	155 658	$126 547	$155 368*

* Divide difference of amount saved from upset price on 50% — 50% basis.

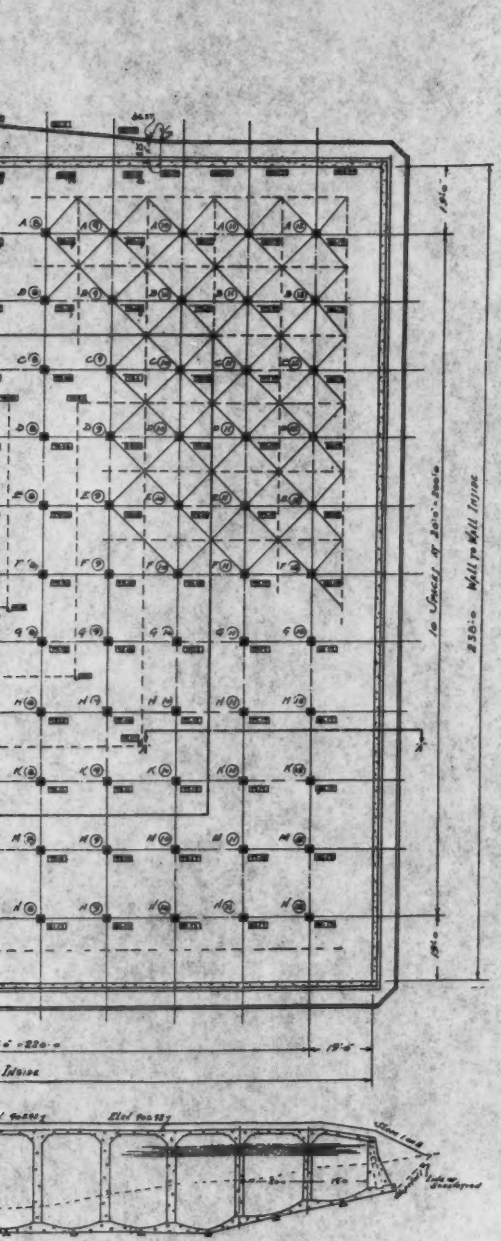
Contract was awarded to the lowest bidder, the Danis-Hunt Construction Company of Dayton, upon designs meeting the specifications though involving a radical modification in type of structure from that originally proposed.

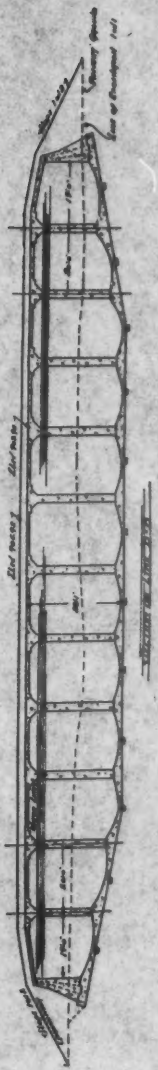
The new plans provided for gravity side walls varying in height with the slope of the ground; a groined arch bottom sloping up on its periphery to meet the most economical wall sections; and a


Note — Wall Between XV & X-V Varies in Height
Gate House
Elev. of Bottom of Wall Fts. at Outside Face
Elev. of Bottom of Fts. at Outside Face
Elev. of Bottom of Wall Fts. at Outside Face
11 Spaces at 20'-0" =220
19'-6"
Wall to Wall Inside
Slope 1 on 2
Natural Surface
Section on Line B-A

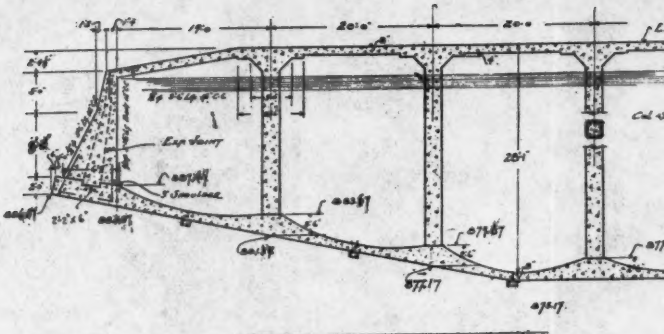
PLAN AND SECTIONS OF

PLATE IV.
N. E. W. W. ASSOCIATION.
VOL. XXXIII.
METCALF AND HARRIS ON
TEN-MILLION-GALLON RESERVOIR,
DAYTON, OHIO.

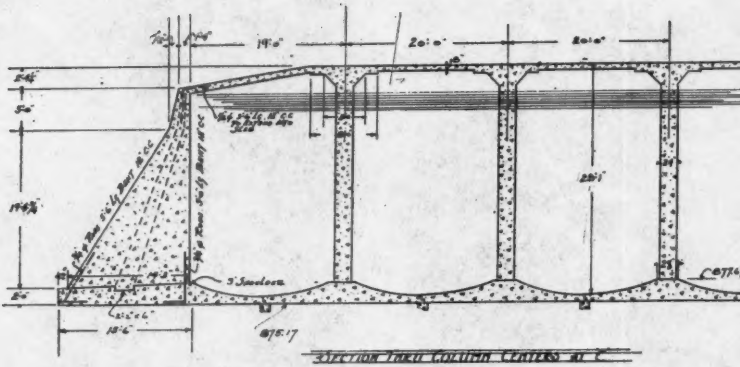




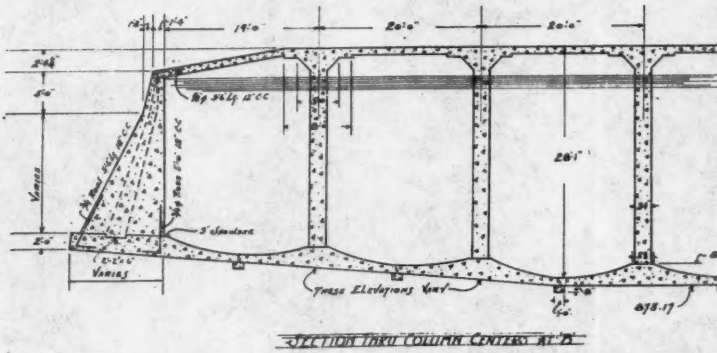
IS OF RESERVOIR AS BUILT.



SECTION THRU COLUMN CENTERS AT A



SECTION THRU COLUMN CENTERS AT C



SECTION THRU COLUMN CENTERS AT B

PLATE V.

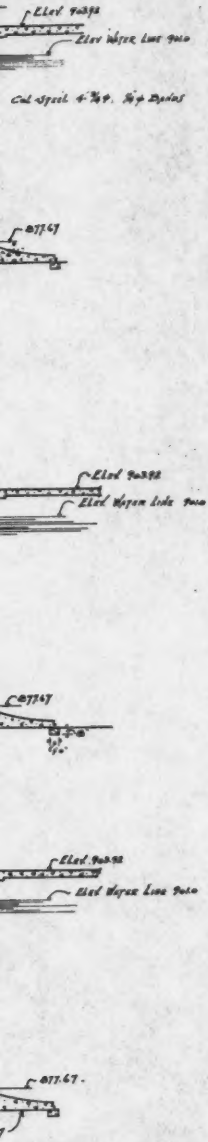
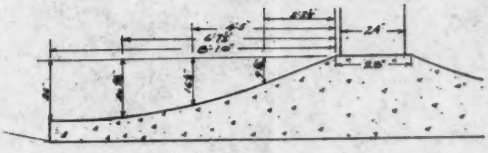
N. E. W. W. ASSOCIATION.

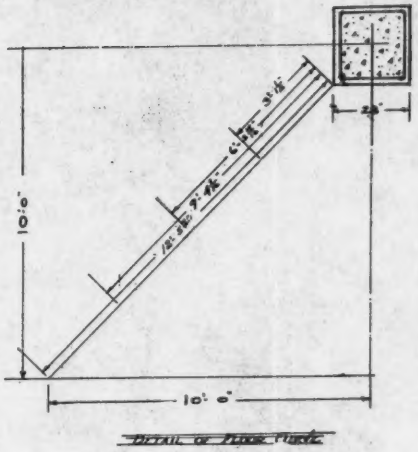
VOL. XXXIII.

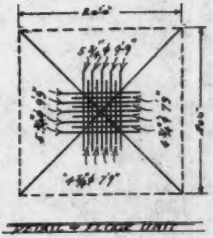
METCALF AND HARRIS ON

TEN-MILLION-GALLON RESERVOIR,

DAYTON, OHIO.







RVOIR AS BUILT.

flat-slab roof of the two-way system, supported on cylindrical columns 26 in. in diameter and 20 ft. on centers. The general type of structure is shown in Plates IV and V and Fig. 2 following.

The preliminary stages leading up to the adoption of the final design have been rehearsed here in some detail because it is interesting to compare the bids upon different types of structure and to note that purely local conditions determined the final choice of type. The local contractors had not had experience with the groined arch type of structure, but had built many flat-slab floors and roofs; and it is also probable that the fact that these contractors had on hand a large supply of wooden forms, which had been used by them in flat-slab construction theretofore, was of substantial moment in determining the bids submitted by them and type of structure proposed. It seems probable that under normal conditions the groined arch design would have commanded the lowest figures, and that advantageous competitive bids for building the structures would have been received from a number of contractors outside of Dayton, as well as from local bidders; but under the abnormal local conditions a different result followed.

The writers are of the opinion that the groined arch type is to be preferred to the flat-slab type for such reservoir structures, on account of greater strength and permanence, but the bids received, under the local conditions then prevailing, were more than enough lower to offset this difference.

Construction.

Excavation. — Excavation was begun by the contractor on October 12, 1917, with Thew steam shovels of the "O" type, having a capacity of from 200 to 500 cu. yd. per day with a $\frac{5}{8}$ cu. yd. dipper, stripping the surface material and depositing it in storage piles adjacent to the work, by means of two-horse hopper-bottom wagons. Two steam shovels were used, — one substantially throughout the job; the other from November 17 to December 6, 1917, although it remained on the work until March 2, 1918. A Keystone excavator of from 100 to 250 cu. yd. capacity, manufactured by the Keystone Drilling Company of Beaver Falls, Pa., was also used during the periods from No-

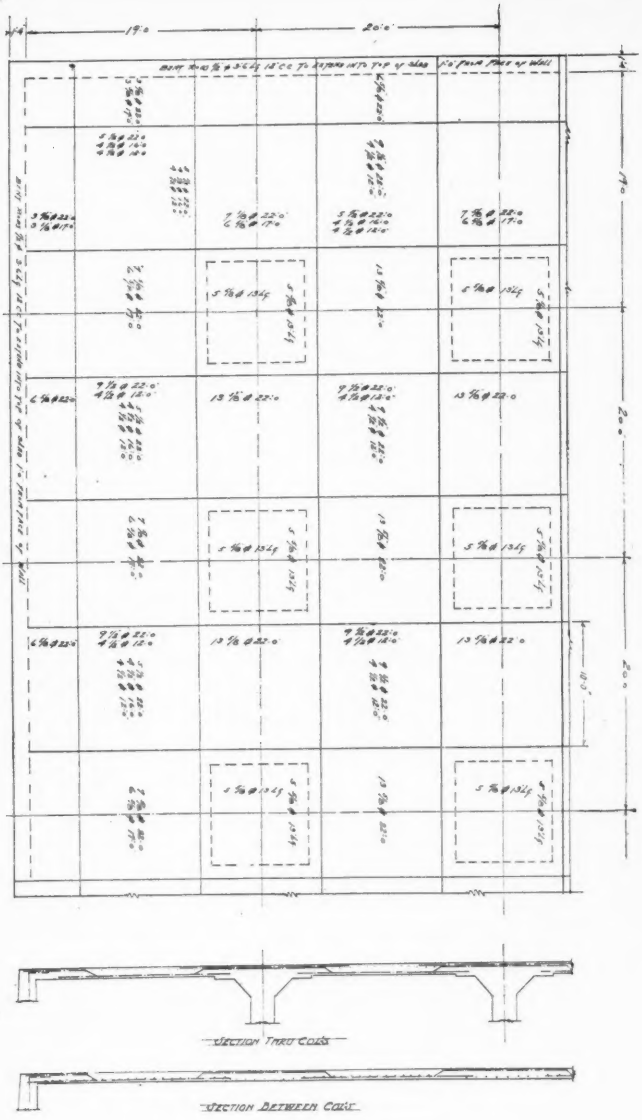


FIG. 2. ROOF SLAB REINFORCING.

vember 12 to December 1, 1917, and March 1 to 25, 1918. The latter machine consists of a tractor engine with trolley boom carrying a scoop shovel of 10 cu. ft. capacity and was used largely for trimming up the rough excavation made with steam shovel, prior to the final preparation of the foundation by hand. Some of the sand and gravel was handled on short haul by slip scrapers.

By these methods 25 000 cu. yd. of material were handled, 45 per cent. of it being delivered to the screening plant located within the lines of the reservoir, for use in concrete aggregates; 30 per cent. being stored and subsequently replaced as backfilling, over and against the completed reservoir; and 25 per cent. being placed directly in the embankment surrounding the structure.

The excavation and resurfacing work was sublet, it is reported, at the following figures:

12 000 cu. yd. 25c. per cubic yard for sand and gravel hauled from excavation to the screening plant.
13 000 cu. yd. 45c. per cubic yard for soil and dirty gravel hauled outside of reservoir walls.
10 000 cu. yd. 56c. per cubic yard from storage pile into backfill.
3 acres at $100 per acre for grassing and seeding.

At these prices the subcontractor must have suffered at least the loss of rental upon his equipment.

The surface and subsoil material consisted of a clayey gravel, varying in depth from 1 to 3 ft. Under this was found a clean, sound, and rather fine gravel. To it was added such coarser material as could be obtained at reasonable cost, from a nearby pit and by rail. All of the concrete aggregates, except about 1 800 cu. yd. of this coarser material, came from the site.

Contractor's Plant.

Screening and Washing of Concrete Aggregates. — The gravel excavated from the site was dumped from hopper-bottom wagons or slip scrapers on a sloping rack of flat bars with $2\frac{1}{2}$ in. clear space. The material fell into a pit from which it was raised by elevator bucket and dumped into a similar bucket arranged with nozzles for washing the gravel, the muddy water overflowing to the waste channel, the washed material being discharged through a

gated opening upon an inclined piano-wire screen 3 ft. by 5 ft., with $\frac{3}{16}$ in. opening. This screen was made by the Manufacturers Equipment Company of Dayton, Ohio. This screen was protected by a series of wires stretched above the screen to divert the heavier material, the fall of which would have injured the

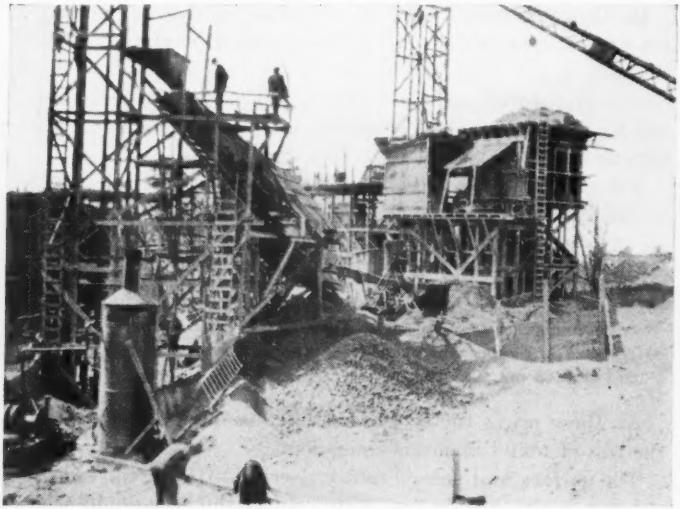


FIG. 3. SCREENING AND MIXING PLANT.

screen. By this means the material was separated into two grades, — sand and gravel.

A stiff-legged derrick with structural steel mast and boom, swung by a bull wheel, was erected at the northeast corner of the reservoir just outside of the structure. Its location was such that with its boom in a fixed elevation the clamshell bucket could cover the sand and gravel piles at the base of the screening plant, the sand and gravel hoppers of the mixing plant, the sand storage pile in the old gravel pit just north of and adjacent to the reservoir structure, and the gravel storage pile just east of the reservoir.

Mixing Plant. — The concrete mixing plant consisted of a Smith type mixer of one cu. yd. capacity, operated by steam

engine, with elevated measuring hoppers, operating platform and small cement storage shed, and with sand and gravel storage bins with hopper bottoms at a still higher level. The storage bins and water tank were fitted with steam pipe coils for use in freezing weather.

The concrete when mixed was discharged into an elevator with self-dumping hopper from which it was dumped into a second hopper located just above the elevated wheeling platform. This hopper was provided with a shear gate for controlling the loading of the concrete buggies.

Miscellaneous Plant. — A cement storage shed, blacksmith shop, tool and supply house, office and stables, all of temporary type, were erected by the contractor and connected with the high-service water supply and electric-lighting systems. A small saw mill was also installed, to assist in the making of forms, though it was used comparatively little. Simple devices were used for bending the structural steel.

Runways. — An elevated platform was erected along the north and west sides of the reservoir, just outside of the neat lines of the structure, from which was poured the concrete for a portion of the floor and walls, the balance of the concrete being poured from runways laid upon the roof forms.

Order of Construction.

After the excavation had been made by steam shovel in the northwesterly corner of the site, the subgrade was prepared by hand shovel. The 8 in. x 12 in. concrete beams were then laid. Next, alternate floor units were placed, — the pier units of the inverted groined arch type, and the marginal units of barrel arch type, extending under the side walls. The concrete in the side walls was then placed in alternate units, one panel (20 ft.) in length, the concrete being poured monolithic from the base of the wall to the roof slab. The alternate floor units previously omitted were then placed, and when a sufficient area of the floor had set, to make working upon it possible, the forms for the columns and the roof were placed. As the slope of the floor of the inverted groined arch units was substantial, the contractor adopted

the expedient of setting iron bolts about 2 in. into the concrete, to support a wooden sill, upon which was then placed the studding to support the roof forms.

The columns were poured monolithic from the floor to the base of the capital, the capital of the column being poured with the roof slab. The roof was placed in sections covering two or more adjacent lines of piers, joints being broken on the mid-sections between the pier lines.

The effort was made to keep the concrete moist until thoroughly set. The difficulty in accomplishing this upon the roof slab, and the development of undesirable cracks where the concrete dried out too rapidly, has suggested to the writers that it would have been desirable to place a ridge of mortar, 1 in. or thereabouts in depth, around the margins of the completed slabs, in finishing the roof, to form shallow basins in which water might be kept standing until the roof concrete had set thoroughly.

To prevent undue leakage through contraction cracks at the ends of the side wall sections, deep tongues and grooves in the thick section of the wall, and 12 in. by $\frac{1}{8}$ in. by 9 ft. 9 in. steel plates through the mid-section of the upper thinner part of the wall were provided.

Forms.

Floor Forms. — The floor form consisted of four steel ribs of T section, bent to the form of the groin or arris, attached to the corners of a 28-in. square steel yoke, forming the base of the column, and suspended from a long wooden horse spanning the floor unit. The exterior forms of the alternate units first placed consisted of 8-in. planks on edge, with a strip slightly beveled and nailed to the upper part of the 8-in. plank, to form the rebate in the upper half of the slab joint, to receive the concrete of the alternate floor units. The perimetral edge of the floor unit rested upon the 8 in. by 12 in. sub-foundation beams previously referred to. In this manner a double-angle cut-off was formed, to prevent leakage. Furthermore the underlying beam served to make possible the introduction of an asphaltic mixture in the joint, at a later date, if it should be found that leakage was produced by

shrinkage cracks in the floor units, without danger of having the water in the reservoir blow this jointing material through the joint to the sub-foundation.

Wall forms were made of 2-in. plank, thoroughly braced with vertical studs secured at the bottom, tied through the concrete with twisted wire, and yoked on top.

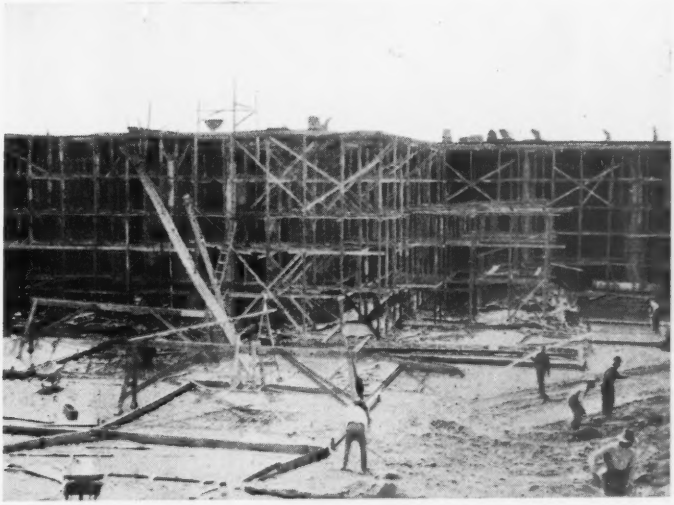


FIG. 4. FLOOR AND ROOF FORMS.

To prevent the lifting of the back form of the side walls by the upward pressure of the plastic concrete as it was placed, $\frac{3}{8}$-in. U-irons were inserted in the floor unit, which extended under the wall, to which the outside wall forms were anchored by twisted wire.

The roof column forms were of steel, built and leased by the Deslauriers Column and Mould Company of Cleveland, Ohio, of a type commonly used in building construction. The details of the column and capital forms are indicated by the accompanying photographs.

The roof forms were supported by 4-in. studs 5 ft. on centers, resting upon 4 by 4 in. sills, braced at intervals and stiffened by

occasional sway bracing and by bracing in horizontal planes approximately 5 ft. apart, as shown in the accompanying photograph.

On top of the wooden columns were placed longitudinal stringers 4 in. by 4 in., and upon them sections of grillage made

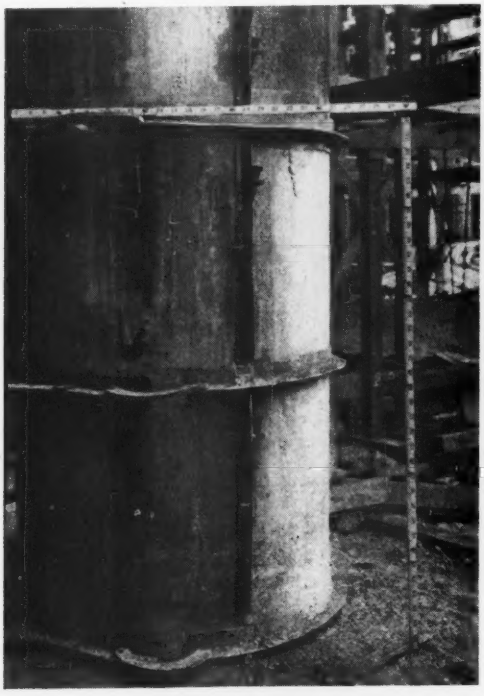


FIG. 5. COLUMN FORM.

up of strips of 2 in. by 3 in. scantling 2 in. apart, secured by cleats and chains, the chains being used so that when the cleats were removed the grillage could be nested in compact form for shipment. On top of this framework was tacked 28 gage sheet steel upon which the concrete was placed. Forms for the dropped panels over the columns were of wood, as appears in the accompanying photographs. This type of form lent itself to ready removal after the setting of the concrete.

FIG. 6. COLUMN FORM DISMANTLED.

FIG. 7. FORMS FOR COLUMN CAPITALS.

FIG. 8. GRILLAGE FOR ROOF FORMS.

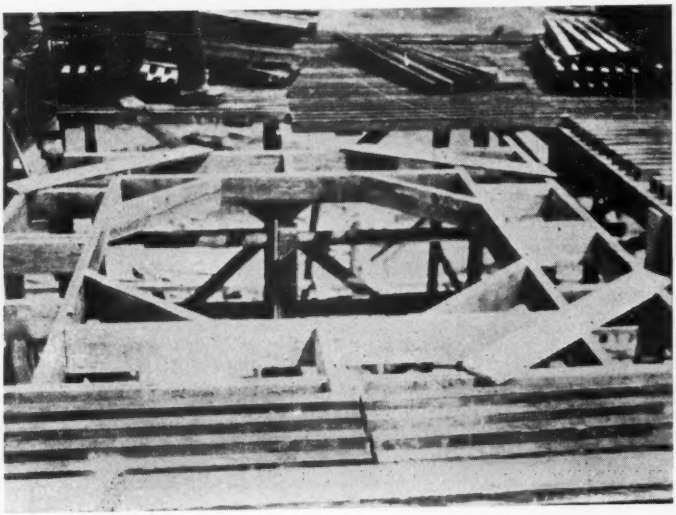


FIG. 9. FORMS FOR DROPPED PANELS.

Concrete Proportions.

Two classes of concrete were used — Class A and Class B:

Class A. — One part by volume of cement and four parts of gravel, to which was added sufficient sand of variable grade, not exceeding two parts, to make a satisfactorily dense mixture.

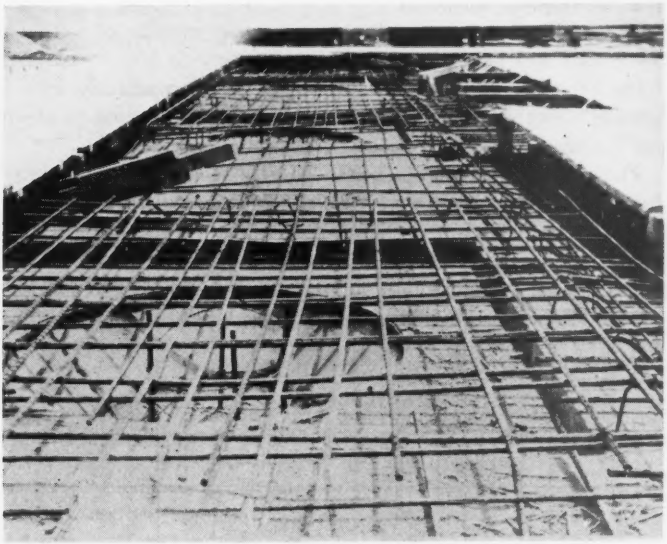


Fig. 10. Reinforcement in Place.

Class B. — One part by volume of cement and five parts of gravel, to which was added sufficient sand of variable grade, not exceeding three parts, to make a satisfactorily dense mixture.

Class A concrete was used throughout the structure, except in the walls. Class B concrete was used for the side walls, which were of heavy gravity section without reinforcement.

Rates of Progress.

Reference has already been made to progress upon the excavation, which was begun on October 12, 1917.

Most of the contractor's plant was assembled and placed during the latter part of November and early part of December.

The first cement shipment arrived on November 30.

Snow fell on December 6, and bad weather continued until December 19, when the work was suspended for the winter, except for one of the steam shovels, which was operated from time to time as weather permitted.

The number of men employed during the months of October, November and December varied from twenty to fifty.

On February 23, 1918, the work was resumed actively with a force of about sixty men, which was gradually increased to about one hundred.

The placing of concrete began March 11 and was completed June 27, 1918. There were placed 8 746 cu. yd. of concrete in seventy-nine days, out of eighty-six available working days, and eighty-one actual working days. The average rate of placing concrete was, therefore, 110 cu. yd. per day of concrete-pouring; 108 cu. yd. per working day, and 102 cu. yd. per available working day.

TABLE 2.

AVERAGE NUMBER OF MEN EMPLOYED DURING CHARACTERISTIC WEEK IN BUILDING THE LOW-SERVICE RESERVOIR.

	Week Ended.		
	April 20.	May 25.	June 8.
Yards of concrete placed	868	907	850
Number of employees:			
Preparing subgrade	10	7	..
Washing and screening sand and gravel	6	10	14
Carpenters	37	27	32
Mixing and placing concrete	22	32	31
Unloading and handling cement	3	3	1
Steel	6	4	4
General work	10	5	7
Total	94	88	89

The maximum amount of concrete placed in one week was 907 cu. yd., averaging for that week (May 20 to 25) 151 cu. yd. per day; the maximum amount on any single day being 226 cu. yd. on June 5.

The approximate number and distribution of men employed during the active progress of the placing of the concrete is shown by the tabulation on page 240, and the rate of progress on the different branches of the work by Fig. 11.

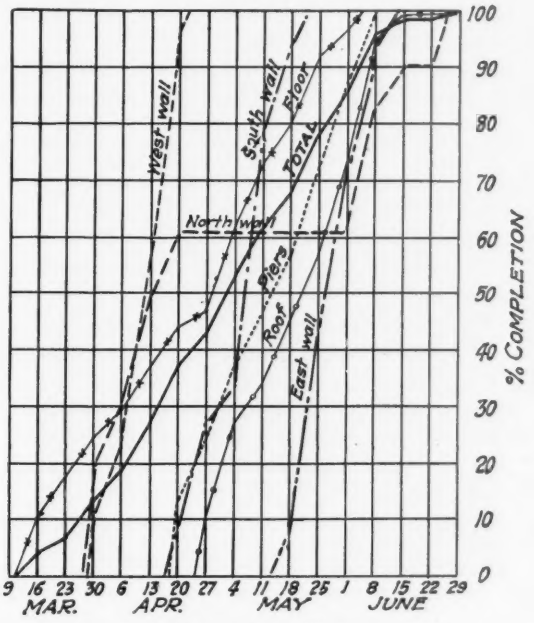


FIG. 11. CONSTRUCTION PROGRESS, 1918.

A reception was held in the reservoir on June 13, 1918, at which time opportunity was given to the public to thoroughly inspect the structure.

The reservoir was cleaned out on July 6, and on July 8 it was filled to a depth of about 11 ft., and one tank containing 80 lb.

of liquid chlorine was lowered into the water and its contents discharged, thus giving the water a dose of 25 lb. of chlorine per million gallons of water. Shortly thereafter the outlet valve was opened and the contents of the reservoir were drained in a period

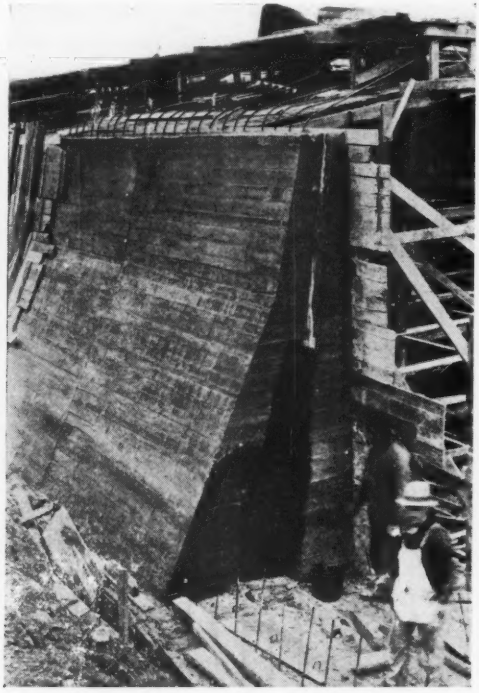


FIG. 12. TYPICAL WALL SECTION.

of about eighteen hours. Men were then sent into the reservoir with a fire hose to wash the entire inner surface of the reservoir down. This took one working day, and on the evening of the same day refilling of the reservoir began and continued for three days, 2 million gallons, more or less, being permitted to overflow into the drain. The reservoir was then put into service, though

it was subsequently thrown out of service for three weeks for a test of leakage and for minor repairs upon the floor joints.

The leakage will be observed from time to time during the cold winter months, and if found to increase materially, the joints

FIG. 13. INTERIOR COMPLETED RESERVOIR.

around the unit pier sections will be treated with an asphaltic mixture.

The general character of the concrete was smooth, dense, and excellent, — thoroughly creditable to the contractor, the Danis-Hunt Construction Company which was experienced in reinforced concrete and flat-slab building construction.

When the reservoir was first tested the leakage was found to be at the rate of 23 in. vertically, or 864 000 gal. per day. The water was withdrawn and cracks were found along the center lines of the floor invert at certain places. These cracks were cut out and filled with mortar.

The reservoir was refilled on August 15, 1918, and the leakage was found to have been reduced to $2\frac{5}{16}$ in. vertically, or 88 000

TABLE 3.

DAYTON, OHIO. — LOW-SERVICE RESERVOIR. — RESIDENT ENGINEER'S BASIC ESTIMATE OF COST TO THE CONTRACTOR (CEMENT FURNISHED BY CITY).

	Contractor's Costs.						
	Labor.	Material and Equipment.	Total Excluding Overhead.	Total Including 10% Overhead.*	Cubic Yards.	Unit Costs.	
						Sub-divided.	Total.
Excavation — by Subcontractor:							
1. Total estimated cost .. $14 450							
2. Less allowance account, concrete aggregate .. 3 000							
	$11 450	.....					
3. *By Contractor's Teams and Labor*	1 922	.....	$14 796	$16 276	13 000 cu. yd.	$1.25	$1.25
4. Cleaning up (one half total, balance charged to concrete).	1 424	.....					
Concrete (exclusive of cost of cement and steel) —							
Field Office Administration:							
5. Superintendent, 150 days.....	1 500	.....					
6. Engineer, 3 months.....	450	.....					
7. Engineer, 2 months.....	400	.....	4 232	4 655	8 746 cu. yd. concrete	.53	.53
8. Carpenter foreman (prior to May 10).....	400	.....					
9. Timekeeper and watchmen.....	1 482	.....					
Sand and Gravel:							
10. 12 000 cu. yd. excavated from site for aggregates (see above)	3 000	.....					
11. Screening and washing gravel from site.....	2 065	.....					
12. 1 800 cu. yd. washed gravel purchased.....	.....	$2 500	10 450	11 495	8 746 cu. yd.	1.31	1.31
13. Washed gravel, labor, unloading	660	.....					
14. Washed gravel, hauling.....	2 225	.....					
15. Mixing and placing.....	9 058	.....	9 058	9 964	8 746 cu. yd.	1.14	1.14

Carpenter Work on Forms and Runways:							
16. Floors	1 536	.....	1 536	1 690	3 425 cu. yd.	.49	Itemized Segregation.
17. North wall and gatehouse substructures	1 675	230	1 905	2 095	1 236 cu. yd.	1.70	
18. West wall	1 311	170	1 481	1 629	938 cu. yd.	1.74	
19. South wall	474	90	564	620	479 cu. yd.	1.29	
20. East wall	416	80	496	546	442 cu. yd.	1.23	
21. Roof	9 280	2 400	11 680	12 848	1 824 cu. yd.	7.05	
22. Piers	521	3 300	3 821	4 203	402 cu. yd.	10.46	
23. General	261	30	291	320	8 746 cu. yd.	.04	
24. *Total forms*	($15 474)	($6 300)	($21 774)	($23 951)	(8 746 cu. yd.)	....	2.74
25. Cement handling and storage	1 737	.....	1 737	1 911	8 746 cu. yd.	.22	.22
26. Steel bars, handling and placing	1 517	.....	1 517	1 669	8 746 cu. yd.	.19	.19
27. Equipment, hauling, erecting, repairing, and removing	4 090	6 000	10 090	11 099	8 746 cu. yd.	1.27	1.27
28. Cleaning up and general work (one half charge to excavation)	1 425	.....	1 425	1 567	8 746 cu. yd.	.18	.18
29. Total concrete exclusive of cement and steel	($45 483)	($14 800)	($60 283)	($66 311)	(8 746 cu. yd.)	....	($7.58)
30. Gatehouse superstructure	174	±1 000	1 174	1 291	.....	....	....
31. Miscellaneous work — estimated	1 020	.....	1 020	1 122	.....	....	....
32. Total cost to the contractor	$61 473	$15 800	$77 273	$85 000	.....	....	....

Contract negotiations begun July 31, 1917.
Contract entered into October 8, 1917.
Excavation begun October 12, 1917.
Concrete begun March 11, 1918.

Work suspended December 20, 1917, to February 23, 1918.
Contract (except gatehouse, backfilling and grading) completed June 27, 1918.
Contract finally completed August 29, 1918.
Entire period of construction — active, 11 months.
Entire period of net working days (only), 145 days.
Concrete construction — available working days, 86.
Concrete construction — days pouring concrete, 79.

* *Note.* — That in addition to this 10% distributed allowance for contractor's overhead there have been separately included Items 5 to 9, aggregating $4 232, or 5.8%, covering Field Office Administration costs, making the total overhead allowance 16.4%.

TABLE 4.

DAYTON, OHIO. — LOW-SERVICE RESERVOIR. — RESIDENT ENGINEER'S ESTIMATED UNIT COST TO THE CONTRACTOR, INCLUDING 5.8 PER CENT. FIELD ADMINISTRATION ITEM AND 10 PER CENT. DISTRIBUTED ALLOWANCE, OR A TOTAL OF 16.4 PER CENT. CONTRACTOR'S OVERHEAD COSTS.

	Excavation other than Cost of Concrete Aggregates ($3 300) Included in Line 3 below.	Concrete.				Gate-house.	Miscel-laneous	Total.
		Floors.	Walls and Gate Cham-ber.	Piers.	Roof.			
Excavation and Backfill:								
1. By subcontract ($15 895)	$12 595	.....	.....	.....	.....	.....	.....	$12 595
2. By contractor's outfit	2 114	.....	.....	.....	.....	.....	.....	2 114
Concrete:								
3. Sand, gravel excavation ($3,300)								
4. Screening and washing ($2 272)	.....	$4 500	$4 070	$526	$2 399	.....	.....	11 495
5. Gravel purchased ($5 923)								
6. Mixing and placing	.....	3 900	3 530	454	2 080	.....	.....	9 964
7. Handling and storing cement	.....	748	676	89	398	.....	.....	1 911
8. Handling and placing steel	.....	222	73	122	1 252	.....	.....	1 669
9. Equipment	.....	4 350	3 925	510	2 314	.....	.....	11 099
10. Field office administration	.....	1 822	1 648	214	971	.....	.....	4 655
11. Forms — Labor and materials	.....	1 815	5 003	4 218	12 915	.....	.....	23 951
12. Cleaning up	1 567	614	554	72	327	.....	.....	3 134
13. Miscellaneous work	.....	.....	.....	.....	.....	.....	$1 122	1 122
14. Gatehouse	.....	.....	.....	.....	.....	$1 291	.....	1 291
15. Total cost to contractor	$16 276	$17 971	$19 479	$6 205	$22 656	$1 291	$1 122	$85 000
Materials furnished by city:								
16. Cement, 12 280 bbls. ($2.14 net)	.....	$10 950	$8 190	$1 290	$5 840	.....	.....	$26 270
17. Steel, 152.52 tons ($80.51)	.....	1 630	540	900	9 210	.....	.....	12 280
18. Pipes and fittings	.....	.....	867	.....	.....	.....	.....	867
19. Lime for waterproofing	.....	372	.....	.....	.....	.....	.....	372
20. Grassing	$150	.....	.....	.....	.....	.....	.....	150

21. Miscellaneous	.....	205	186	24	194	40	511	1 160
22. Miscellaneous — Sewer	.....	.....	.....	.....	.....	.....	508	508
23. Miscellaneous — Self-recording level gage	.....	.....	.....	.....	.....	.....	198	198
24. Total materials furnished by city	$150	$13 157	$9 783	$2 214	$15 244	$40	$1 217	$41 805
25. Contractors cost plus cost to city of materials furnished	16 426	31 128	29 262	8 419	37 900	1 331	2 339	126 805
26. Yardage — Cubic yards	‡13 000	3 425	3 095	402	1 824	.....	.....	8 746 (Concrete)
Unit Costs (see Note † below):								
27. Work done by contractor	$1.25	$5.24	$6.29	$15.44	$12.42	$0.15	$0.13	$9.72
28. Materials furnished by city	.01	3.84	3.16	5.51	8.36	.....	0.14	4.78
29. Total †	$1.26	$9.08	$9.45	$20.95	$20.78	$0.15	$0.27	$14.50

SUMMARY OF UNIT COSTS OF CONCRETE TO CONTRACTOR PLUS MATERIALS FURNISHED TO HIM BY THE CITY.

Concrete:					
30. Sand and gravel	.....	$1.31			
31. Mixing and placing	.....	1.14			
32. Handling and storing cement	.....	.22			
33. Equipment	.....	1.27	$4.65	$4.65	$4.65
34. Cleaning up (one half charged to earth)	.....	.18			
35. Field office	.....	.53			
36. Handling and placing steel	.....	.06	.02	.30	.69
37. Forms	.....	.53	*1.62	10.49	7.08
38. Materials furnished by city	.....	3.84	3.16	5.51	8.36
	.....	$9.08	$9.45	$20.95	$20.78

* Labor and materials for north and west walls + gatehouse foundation cost, $1.71; labor and materials for south and east walls (Lighter Section), $1.27.

† Excavation cost based upon cubic yards of excavation other than for concrete aggregates; concrete costs based upon cubic yards actually involved in different classes of work, such as floor, walls, piers, and roof; gatehouse superstructure and miscellaneous costs based upon total amount of concrete, 8 746 cu. yd; total unit cost based upon total concrete, 8 746 cu. yd.

‡ Excluding 12 000 cu. yd. of sand and gravel used as concrete aggregates and included under concrete cost items.

TABLE 5.

DAYTON, OHIO. — LOW-SERVICE RESERVOIR. — RESIDENT ENGINEER'S ESTIMATED UNIT COST TO THE CITY.

	Excavation.		Concrete.				Gatehouse.	Miscellaneous.	Totals.
	Loam.	Earth.	Floors.	Walls and Gate Chamber.	Piers.	Roof.			
Excavation	$10 000	$15 000	.....	.....	.....	.....	.....	.....	$25 000
Grassing (half done)	150	.....	.....	.....	.....	.....	.....	.....	150
Handling cement	.....	.....	$2 560	$1 915	$300	$1 365	.....	.....	6 140
Concrete	.....	.....	10 275	18 570	5 025	22 800	.....	.....	56 670
Handling steel	.....	.....	400	.....	.....	3 415	.....	.....	3 815
Handling plates	.....	.....	.....	87	.....	.....	.....	.....	87
Handling metal and pipes	.....	.....	.....	400	.....	.....	.....	.....	400
Dressing concrete	.....	.....	.....	79	.....	.....	.....	.....	79
Unloading lime	.....	.....	24	.....	.....	.....	.....	.....	24
Gatehouse	.....	.....	.....	.....	.....	.....	$1 500	.....	1 500
Cleaning up	200	300	196	177	27	100	.....	.....	1 000
Total payment to contractor	$10 350	$15 300	$13 455	$21 228	$5 352	$27 680	$1 500	.....	$94 865
Materials furnished by city, cement, 12,260 bbl., $30 690 less sack credits, 4 420	.....	.....	$10 950	$8 190	$1 290	$5 840	.....	.....	$26 270
Steel, 152.52 tons	.....	.....	1 630	540	900	9 210	.....	.....	12 280
Pipes and fittings	.....	.....	.....	867	.....	.....	.....	.....	867
Lime for waterproofing	.....	.....	372	.....	.....	.....	.....	.....	372
Grassing	$150	.....	.....	.....	.....	.....	.....	.....	150
Miscellaneous	.....	.....	205	186	24	194	$40	$511	1 160

Miscellaneous — Sewer	.....	.....	.....	.....	.....	.....	.....	508	508
Miscellaneous — Self Recording level gage	.....	.....	.....	.....	.....	.....	.....	198	198
Total materials furnished	$150	.....	$13 157	$9 783	$2 214	$15 244	$40	$1 217	$41 805
Land	.....	.....	.....	.....	.....	.....	.....	7 030	7 030
Engineering (6%), administration (5%)	683	994	1 730	2 016	492	2 790	100	536	9 341
Total cost to the city	$11 183	$16 294	$28 342	$33 027	$8 058	$45 714	$1 640	$8 783	$153 041
Yardage — Cubic yards	5 000	20 000	3 425	3 095	402	1 824	(8,746 cu. yd. conc.)		8 746
Unit cost to city for:									
Work done by contract	$2.07	$0.76	$3.93	$6.86	$13.31	$15.17	$0.18	.....	$10.85
Materials furnished	.03	.....	3.84	3.16	5.51	8.36	.....	$0.14	4.78
Land	.....	.....	.....	.....	.....	.....	.....	.80	.80
Engineering and administration	.14	.05	.51	.65	1.22	1.53	.01	.06	1.07
Total per cubic yard	$2.24	$0.81	$8.28	$10.67	$20.04	$25.06	$0.20	$1.00	$17.50

Total per million gallons of reservois capacity (10 m.g.)	$15 300
Total per square foot of water surface (60 917 sq. ft.)	2.51
Total per acre of water surface (1.4 acres)	109 300

gal. per day. Since that time the reservoir has been in active service, and the latest observation upon leakage, November 20, 1918, or thereabouts, indicated a loss of $1\frac{1}{4}$ in. vertically, or 48 000 gal. in twenty-four hours.

Cost.

The wages paid by the contractor increased progressively from 30c. to $38\frac{1}{2}$c. per hour for unskilled labor; from 50c. to $60\frac{1}{2}$c. per hour for carpenters; from 55c. to 65c. for engine men; and from $60\frac{1}{2}$c. to 70c. for foremen. Teams were paid 60c. per hour.

It may be noted that in 1918 (except from April 2 to 8) wages were based on ten hours of work at eleven hours' pay, equivalent to time and one-half for the hours worked, in excess of the normal eight-hour working day.

In Table 3 is shown the basic estimate of cost to the contractor of doing this work, exclusive of the materials furnished by the city, and in Table 4 these costs have been segregated to show the total and unit costs of the concrete in floors, walls, roof and piers, with and without materials furnished by the city. In Table 5 is shown the estimated cost to the city.

	Contractor's Cost (Excluding Profit) Plus Cost to City of Materials Furnished by It to Contractor.	Total Cost to City of Dayton.	
		Excluding Land and Engineering.	Including Land and Engineering.
Gross cost	$126 805	$136 670	$153 041
Cost per cubic yard of concrete (8 746 cu. yd.)	14.50	15.63	17.50
Cost per million gallons of net water capacity	12 680	13 667	15 300
Cost per square foot of water surface (based upon 60 917 sq. ft. of water of 23.5 ft. average depth)	2.08	2.24	2.51
Cost per acre of net water surface (60 917 sq. ft. or 1.4 acres)	90 600	97 700	109 300

TABLE 6.

DAYTON, OHIO. — TEN-MILLION-GALLON LOW-SERVICE RESERVOIR. — CONSTRUCTION UNITS GROINED ARCH (INVERTED) FLOOR; INSIDE DIMENSIONS 258 FT. X 238 FT.; PIERS 26 IN. DIAM., 20 FT. C.C. GRAVITY SIDE WALLS; WATER SURFACE (NET) 60 917 SQ. FT.; REINFORCED CONCRETE SLAB ROOF: WATER DEPTH 23.5 FT., AVERAGE.

	Concrete.		Steel Reinforcement.				Cement.			
				Lb. per Sq. Ft.					Barrels per Cu. Yd. of Concrete.	
	Cubic Yards.	Equivalent Depth on Internal Area of Reservoir, Ft.	Pounds of Steel.	Outside Face of Wall at Top. (61 404.)	Inside Face of Wall. (Gross.)	Lb. per Cu. Yd. Concrete.	Proportions.	Barrels.*	Hypothesis A.	Hypothesis B.
Floor (incl. wall base)	3 425	1.51	40 550	0.64	6.66	11.8	1:2:4	4 450(?)	1.30	1.50 ±
Walls and gate chamber	3 095	1.36	13 720	0.22	0.22	4.4	1:2½:5	4 515(?)	1.46	1.24 ±
Roof	1 824	.80	228 440	3.63	3.72	125.0	1:2:4	2 715	1.49	1.50
Piers	402	.18	22 490	0.36	0.37	56.0	1:2:4	600	1.49	1.50
Total	8 746	3.85	305 200	4.85	4.97	34.9	....	12 280	1.40	1.40

* These records are not precise in any event, and they may be inaccurate. The keeping of the correct record of subdivision of bags of cement on different parts of the structure was very difficult. The " Hypothesis A " results are based upon the actual recorded segregation of cement used in about 38% of the floor masonry, 11% of the walls, 25% of the roof, or on 25% of the total masonry. " Hypothesis B " results represent the approximate theoretical division.

The total cost to the contractor is estimated at the sum of $85 000 (excluding profit item and materials furnished to contractor by the city); the cost to the city at the sum of $153 041 (including $7 030 for land, $41 805 for materials, and $9 341 for engineering and city administration). This results in the unit costs on page 250.

In Table 6 are given the amount and equivalent depths of concrete; the total weight and pounds of steel reinforcement per square foot of internal area of the reservoir; the number of barrels of cement and amount used per cubic yard of concrete.

Acknowledgments.

The work was executed under the authority and direction of Col. H. M. Waite, member American Society of Civil Engineers, city manager at its inception; Mr. J. E. Barlow, member American Society of Civil Engineers, director of Public Service, who succeeded Mr. Waite as city manager when the latter entered the military service in the spring of 1918; and Mr. H. C. Wight, member American Water Works Association, superintendent of the Division of Water, all of whom took active and helpful interest in the work and its progress.

The Danis-Hunt Construction Company was the contractor, Mr. Benjamin G. Danis having general supervision of the work. The alternative design submitted by the contractor was prepared by the company's engineer, Mr. Nelson J. Bell, under the general direction of Mr. Danis.

The original and modified designs were prepared by Mr. Frank A. Marston, of Metcalf & Eddy, who were the designing and supervising engineers upon this work.

The construction was in the immediate charge of Mr. Barnes; Mr. Gilman W. Smith, former division engineer of the American Bridge Company, was resident engineer, — and was succeeded, when he entered the government war service, by Mr. David A. Hartwell, city engineer and formerly chief engineer of the Sewage Disposal Commission of the City of Fitchburg, Mass.

Summary.

1. A covered masonry reservoir of 10 million gallons capacity was built for the Water Department of the City of Dayton, Ohio, in the year 1917–18, to equalize the hourly fluctuations in water demand; to facilitate the making of minor repairs at the pumping station; and to provide fire service storage capacity corresponding to the 1916 Standard of the National Board of Fire Underwriters.

2. The variation in rate of pumping at the main pumping station, to meet the demands of domestic, commercial, and industrial water service, was from about 6 million to 35 million gallons per day. The storage required to equalize the hourly variations was approximately 3 million gallons, or 25 per cent. of the average daily water consumption.

3. The fire supply storage capacity required by the National Board of Fire Underwriters (1916 Standard), corresponding to a ten-hour flow at maximum fire demand, was approximately 7 million gallons.

4. The sum of these two amounts (3 million and 7 million gallons) determined the capacity of the structure, which was reduced to the minimum on account of the difficulty and high cost of construction during war times.

5. The reservoir was built of concrete with walls of gravity section; inverted groined arch floor with 8-in. crown thickness; and 26 in. reinforced cylindrical concrete columns varying in length from about 20 ft. to 26 ft., supporting a flat-slab concrete roof $8\frac{3}{8}$ in. thick, reinforced with corrugated bars on the two-way system.

The original design prepared by the engineers for this work contemplated the construction of a groined arch floor and roof type of structure, with lighter walls than those finally used. This design was modified, however, on account of war conditions which made it impossible to secure outside bids and on account of the fact that the local bidders were more familiar with and better equipped to build the flat-slab roof construction and were therefore ready to submit relatively lower figures upon this type of construction than upon the groined arch structure. The unusual saving in cost here found justified the acceptance of a type of structure believed to have a somewhat smaller factor of safety and shorter life.

6. The method of performing the work is described in the text and illustrated by plates and photographs.

7. The total cost of the work to the contractor, excluding profit but including the cost of the materials furnished to him by the city, was $126 805, equivalent to $14.50 per cu. yd. of concrete; $12 680 per million gallons of net storage capacity; $2.08 per sq. ft. of net water surface, and $90 600 per acre of net water surface, — the water surface being approximately 60 917 sq. ft., or 1.4 acres, and its depth averaging approximately 23.5 ft.

8. The total cost to the city of Dayton, including the land and engineering, was approximately $153 041, equivalent to $17.50 per cu. yd. of concrete; $15 300 per million gallons of net water capacity; $2.51 per sq. ft. of water surface, and $109 300 per acre of water surface.

9. The character of the finished work was excellent, the concrete being dense and reasonably smooth.

10. The leakage of the finished structure was found to be $2\frac{5}{16}$ in. vertically, or 88 000 gal. per day, and three months after putting the reservoir into service $1\frac{1}{4}$ in. vertically and 48 000 gal. per day.

Discussion.

Mr. Caleb M. Saville. Mr. Barnes spoke of a method for keeping the top of the chamber damp or wet. I would say that we are constructing a groined arch chamber, using groined arch construction. We are finding it very advantageous to keep the chambers full of water all the time. We keep it up to the top of the arch. It makes it very convenient.

Mr. Frank L. Fuller. Mr. Barnes told me that I might show a slide of the roof of a 1 600 000 gal. covered reservoir, flat slab, which was constructed for the town of Webster in 1914, which, in connection with Mr. Barnes's very interesting account of this much larger reservoir, may be of interest. [*Stereopticon picture is shown on screen.*]

The side walls were rectangular, a foot and a half thick at the bottom and a foot thick at the top; the slab was a foot in thickness; all walls were made of concrete.

There is a ring which perhaps you may not be able to distinguish, which is $1\frac{1}{2}$ in. in diameter and welded. I think the diameter was 5 ft. The piers were 16 in. square, and on to them were hooked these radial bars, which were $\frac{3}{4}$ in. Intermediate was various other reënforcement, so that the roof has shown no cracks, and fortunately has done very good work.

The total cost of the reservoir was $20 020, and the cost per thousand gallons was figured at $12.50. I think the cost of Mr. Barnes's reservoir, as I remember his figures, was about $12.68, and I think those figures coincide very closely. These prices were probably too low. The people that built this reservoir, although they were perfectly capable of doing almost any kind of a job, had not had much experience in such work. For instance, the excavation was 62 cents a cubic yard; the rock excavation, $4; concrete in the walls and footings, $10; cut-off wall around the piers, $10.50; column heads and foundation, $11.25; roof, $12.25; the bottom, $8; reënforcing steel in columns and foundation, $3\frac{3}{4}$ cents; in the side walls, 3 cents; in the roof, 4 cents. The pipe laying was 75 cents — that was 20-in. pipe.

Those are the principal items. And, as I said, the total cost was $20 020. The wall was reënforced by round bars, and the columns also by round bars with 1-in. corner.

I have the cost per thousand gallons of several other forms of reservoir roof. I do not know whether this reservoir could have been built cheaper if it had been built on the groined arch principle; I never figured that out to see what their prices would have been, and I do not know. It seems to me that the circular from of reservoir is the most economical and the most practical, and either a flat slab or something other than groined arch construction would fit better.

I have built several circular reservoirs, but never a groined arch roof on a circular reservoir. I have built some on some rectangular reservoirs. But it seems to me that a groined arch roof would not fit a circular reservoir very well.

I should have said that Mr. Sanford E. Thompson designed the reservoir.

Mr. Morris Knowles. It appears from the pictures that Mr. Barnes showed us that the floor slabs were formed with centers

coincident with the center of the pier, the slabs parallel with the line of the piers and midway between the lines of piers. If this be so, it appears that the process of screeding would be rather difficult, and it would be interesting if Mr. Barnes would explain the method used.

MR. BARNES. If you notice the floor forms in one of the photographs; they were made of T-irons swung from a yoke that was hung from a long 22-ft. horse over the top, and the ends of those T-irons were held to the square form forming the outside of the unit. They used a long screed, about 21 ft. long, and those ribs as forms, and there was very little difficulty, with a strong man on either end and one in the middle, in preventing sagging from the screed, then finishing with the ordinary trowel when the concrete was dense enough to permit it.

MR. KNOWLES. The T-iron had to be elevated at the last to finish the surface?

MR. BARNES. At the very end it was withdrawn and a little mortar put into the space left by the vertical part of the T. It worked very well, apparently, with a good strong arm on either end of the screed.

SCHOHARIE DEVELOPMENT, CATSKILL WATER SUPPLY SYSTEM FOR NEW YORK CITY.

BY J. WALDO SMITH, CHIEF ENGINEER, BOARD OF WATER SUPPLY, NEW YORK CITY.

Construction work for the Schoharie development is now under contract. This source is a part of the original project to secure a supply of not less than 500 million gallons of water a day from the Catskill Mountain sources, as planned by the Board of Water Supply and approved by the Board of Estimate and Apportionment of the city of New York in 1905. The original plan has been amended in detail, or perhaps it may rather be said that the plan as now being constructed has developed somewhat differently than originally outlined. The total supply for the Catskill aqueduct will be obtained from the Esopus and Schoharie sources — not less than 250 million gallons a day from each — at a less cost than was originally estimated for securing the same amount of water from the three sources of Esopus, Rondout, and Schoharie creeks.

The Esopus watershed development, which will furnish not less than 250 million gallons per day by the construction of the Ashokan reservoir, has been completed. The Catskill aqueduct, having a capacity of not less than 500 million gallons a day, and the necessary appurtenant works have also been completed. These, together, constitute the first stage of construction and have been in continuous operation since January 27, 1917, the first Catskill water having been delivered to the city on December 27, 1915. These works were turned over to the operating department on August 1, 1917.

The Schoharie watershed is adjacent and contiguous on the north to the Esopus watershed, the divide being the main ridge of the Shandaken Mountains. Drainage from the Esopus water-

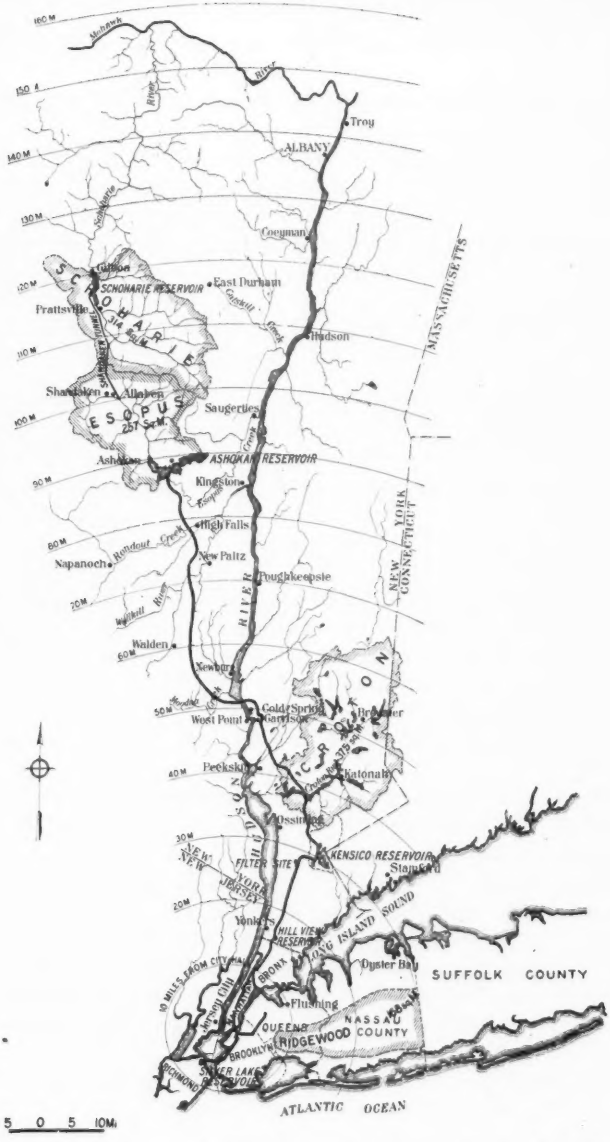


FIG. 1. SCHOHARIE AND ESOPUS DRAINAGE AREAS, CITY OF NEW YORK WATER SUPPLY.

shed is naturally through Esopus Creek eastward into the Hudson River. Drainage from the Schoharie watershed, on the other hand, is northward into the Mohawk River. The general elevation of the upper reaches of Schoharie Creek is slightly higher than the Esopus Creek, so that an impounding reservoir and a long tunnel through the divide are the works that will be necessary to join the Schoharie watershed to the Catskill system. Thus the Catskill system will be extended northerly 36 miles from the Ashokan dam, making the total over-all distance of the Catskill system, from the Gilboa dam to the terminal reservoir in Staten Island, 156 miles.

The waters of Schoharie Creek will be impounded in a reservoir of 20 billion gallons capacity, formed by the construction of a dam in the town of Gilboa, Schoharie County, the flow line of the reservoir being at an elevation of 1 130 ft. above sea level. The water will then be diverted from this reservoir through an 18-mile tunnel under the Shandaken Mountains into the upper reaches of Esopus Creek, at the village of Allaben, Ulster County, where the elevation is about 969 ft. The Schoharie waters, having thus been discharged into the natural bed of Esopus Creek, will join the natural flow of Esopus Creek and follow the natural stream bed for a distance of 11 miles into the Ashokan reservoir, where it is available for the Catskill aqueduct. Thus, in effect, the Schoharie, with its drainage area of 314 square miles above the dam, will be added to the drainage area of the Esopus Creek, which is 257 square miles above the Ashokan dam, forming together practically one drainage area of 571 square miles.

The Schoharie reservoir, of 20 billion gallons storage capacity, is very small for the extent of its contributing area and would be insufficient had not the Ashokan reservoir been constructed of the largest practicable size, 128 billion gallons, which provides for more storage of Schoharie water in the Ashokan than will be provided in the Schoharie reservoir itself. It is therefore seen that the Schoharie reservoir is, in effect, a large diverting reservoir, and it will be so operated.

The Schoharie tunnel will be constructed so as to have a carrying capacity of approximately 600 million gallons of water a day. With this arrangement our studies indicate that during the high-

est floods of nearly every year there will be a waste of a few days' duration, both from the Schoharie reservoir and the Ashokan reservoir. Studies also indicate that during a series of normal years the Schoharie and Esopus, with these two reservoirs, will supply about 600 million gallons a day, securing upward of 80 per cent. of the total flow of the Schoharie Creek and upward of 80 per cent. of the total flow of the Esopus Creek. Studies also show that during a series of dry years, such as the period around 1880, deduced from comparison with Croton records and a study of the long-time rainfall records from New York to Albany, a supply of 500 million gallons per day can surely be secured. During such a dry period or any subnormal year the total flow of both streams will be impounded.

The complete Catskill system, with the Schoharie and Ashokan impounding reservoirs, together with the Kensico emergency reservoir near the city, will have the following features:

Reservoir.	Drainage Area. Sq. Miles.	Reservoir Area. Sq. Miles.	Available Storage. Million Gallons.	Probable Mean Stream Flow. Million Gallons a Day.
Ashokan storage	257	12.78	128 000	361
Schoharie storage	314	1.83	20 000	406
Catskill Mt. sources	571	14.61	148 000	767
Kensico emergency	22	3.47	29 000	18
Total Catskill system	593	18.08	177 000	785

These large yields are due to the generally high elevation of the watersheds and their steep and rocky character. While there are no Alpine heights, the watersheds are composed almost entirely of mountainous ridges covered with wild forest growths and outcropping ledges of shale and sandstone rocks cast up in steep and rugged slopes. There are no mountain peaks over 4 000 ft. in elevation, but the ridges which approximate this elevation for the most part and the intervening valleys in which the tributaries have their sources lie at elevations upward of 2 000 ft. The rainfall is abundant and quickly finds its way to the watercourses. There are generally large freshets in the spring, due to heavy rainfalls in connection with the melting of the deep snows,

with a complementary summer flow which for several months in most years is negligible in amount. Of the 47-in. depth of rainfall in a year on the Esopus watershed, 29.5 in. (63 per cent.) appears as stream flow, while the Schoharie, with only 39.5 in. of rainfall, yields 27.2 in. (69 per cent.) as stream flow. Compared with these, from published data the Croton yields 22.4 in. of stream flow and the Wachusett watershed, of the Boston supply, yields but 21.3 in. of stream flow, on the average.

The character of the Schoharie water is practically the same as that of Esopus Creek, both being of the greatest excellence for potable and domestic purposes. The water is soft, as there are no limestone outcrops, the bed rocks being entirely of shale and sandstone. The Schoharie and Esopus watersheds are dotted here and there by small villages, and the population is small and of a rural character. The villages within the Schoharie watershed are quite well known and may serve to locate the district. They are Hunter, Windham, Prattsville, and Grand Gorge, in Greene, Delaware, and Schoharie counties. A sanitary survey of the watersheds shows a permanent population on the Esopus of 5 339, with an additional summer population of 5 674, giving a density of population for Esopus of 21 for permanent population and a total of 43 per square mile for the total summer population. On the Schoharie the permanent population is 8 792, with an additional summer population of about 6 000, giving a density of population of 28 per square mile of permanent population and 48 per square mile of total summer population. These densities compare very favorably with published information on other watersheds. There is no probability of an appreciable increase of population, as the census figures indicate that there has been no increase in these townships for several decades and, in many cases, there has been a decrease.

The estimated cost of the Schoharie development with the dam at Gilboa is $22 175 400. Having moved the dam site downstream from the approved location at Prattsville to Gilboa, and having changed also the proposed location of the tunnel to Esopus Creek, it was necessary to have the amended plan approved by the constituted authorities. This amended plan with the dam at Gilboa was approved by the Board of Water Supply on December

21, 1915, by the Board of Estimate and Apportionment on January 31, 1916, and by the State Conservation Commission on June 6, 1916.

It is interesting to note — and this was a very forceful argument in proceeding with the construction work on the Schoharie at this time of excessive prices — that similarly, as the introduction of Esopus water to the city in 1917 saved the city $1 300 000 a year for pumping water from sources, so also will the introduction of Schoharie water, about the end of 1924, again save the city that amount, or more, because at that time, undoubtedly, pumps will be in full operation again, the pump supply now being used as a reserve to take up the increased demand from year to year, and as a reserve in case of emergency. This amount saved for pumping will more than meet the interest and sinking fund charges for the Schoharie project, and the city will get the permanent works, delivering 250 million gallons of water a day, against the 150 million gallons pumped, and it will also have the pump supply system in reserve.

The Catskill Creek watershed, which the city had the necessary authority to develop, was put to one side as a possible future source of supply in case of necessity because of the excessive cost of the works, estimated at $41 880 000 for a supply of 120 million gallons of water a day.

The Rondout Creek watershed, which the city also had the necessary authority to develop, was abandoned in 1914 because no location could be found where the foundation conditions were suitable for a dam. At the most favorable site a preliminary estimate showed that the cost of the works would be excessive, — $22 111 000 for a supply of 140 million gallons of water a day.

Preliminary Work and Acquisition of Property.

The land-taking surveys for the Schoharie work were begun in July, 1916, and detailed subsurface investigations by borings for the tunnel location and for the dam foundation were prosecuted in 1916 and 1917. This work was at first concentrated on the tunnel, as it will take longer to construct than to build the dam. There were 16 800 lin. ft. of borings made in definitely fixing the

tunnel line, grade and shaft sites, while an additional 8 400 lin. ft. of borings were made at the Gilboa dam site, these together totaling 4.8 miles, in addition to the 5.0 miles of preliminary borings put down in locating the dam site. The agreement prices of these borings ranged from $2.25 to $3.00 per lin. ft., the average price being $2.50.

The property has been acquired by condemnation, as provided by the special act under which the Board is operating. There is a provision by which title becomes vested in the city at the time the Commissioners of Appraisal file their oaths of office and upon the city paying one half the assessed valuation. The city became vested with the real estate, 80 acres fee, 49 acres easement, total 129 acres for the tunnel and shaft sites, on May 25, 1917, and that for the reservoir, 2 372 acres fee with 2 acres road easements, on November 24, 1917, aggregating 2 503 acres. The preliminary work of definite location and surveying, mapping and formalities of securing the property thus consumed about a year and a half from the date of the final approval of the project.

The Gilboa Dam.

Contract 203, for the Gilboa dam and appurtenances, was awarded on June 23, 1919, to the Hugh Nawn Contracting Company, Roxbury, Mass., the amount, based upon contract quantities and unit prices, being $6 819 910. The dam will be located in the town of Gilboa, Schoharie County, about four miles northeast of the Grand Gorge station of the Ulster and Delaware Railroad. This is 66 miles by rail from Kingston, and 155 from New York. The dam will be located on the present site of the village of Gilboa, which, with its population of about 300, is the only village to be obliterated.

The dam will be of two distinct types. On the east side of Schoharie Creek and in the bottom of the stream the rock is at or near the surface. On this rock foundation will be constructed an overfall masonry portion, 1 300 ft. long and 160 ft. high. The west bank is composed of a very stiff, impervious clay which extends in every direction, and the pre-glacial gorge of the stream is completely filled and deeply covered with tight and impervious

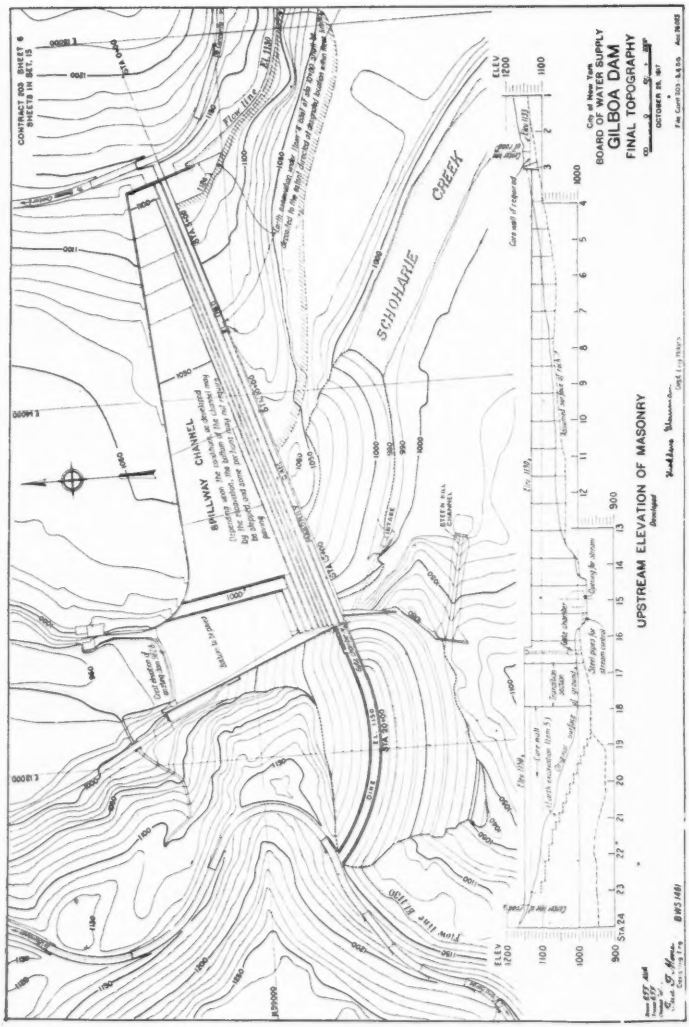

SCHOHARIE CREEK
SPILLWAY CHANNEL
BOARD OF WATER SUPPLY
GILBOA DAM
FINAL TOPOGRAPHY
UPSTREAM ELEVATION OF MASONRY

FIG. 2.

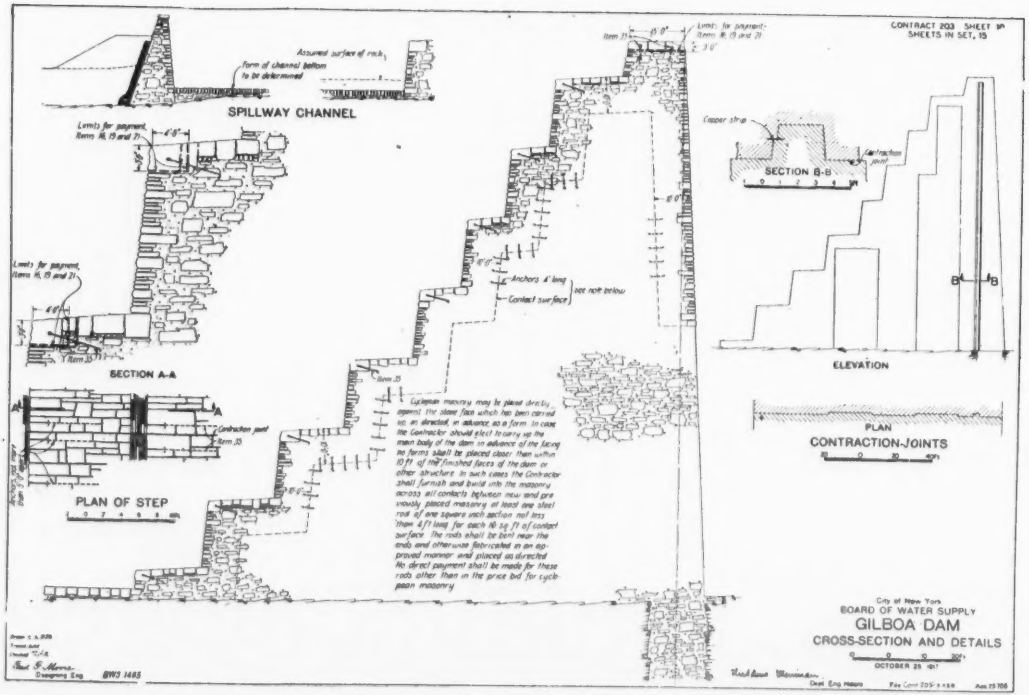

SPILLWAY CHANNEL
Assumed surface of rock
Form of channel bottom to be determined
Limits for payment, Items 16, 19 and 21
SECTION A-A
PLAN OF STEP
Contraction joint
Item 35
Anchors 4' long
Contact surface
see not below
Cyclopean masonry may be placed directly against the stone face which has been carried up as directed, in advance as a form. In case the Contractor should elect to carry up the main body of the dam in advance of the facing the forms shall be placed closer than within 10 ft. of the finished faces of the dam or other structure. In such cases the Contractor shall furnish and build into the masonry across all contacts between new and previously placed masonry at least one steel rod of one square inch section nor less than 4 ft long for each 16 sq ft of contact surface. The rods shall be bent near the ends and otherwise fabricated in an approved manner and placed as directed. No direct payment shall be made for these rods other than in the price bid for cyclopean masonry
Copper strip
Contraction joint
SECTION B-B
ELEVATION
PLAN
CONTRACTION-JOINTS
CONTRACT 203 SHEET 9 OF SHEETS IN SET, 15
City of New York
BOARD OF WATER SUPPLY
GILBOA DAM
CROSS-SECTION AND DETAILS
OCTOBER 25 1911
Chief Engr.
Dept. Eng. Hdqrs.
BWS 1485

FIG. 3.

material. For this side of the stream an earth embankment portion, 1 000 ft. long and approximately the same height as the masonry portion, will be built. At the transition section the dam will be flanked both upstream and downstream by a heavy masonry retaining wall to intercept the long slopes of the earth section.

The overfall section is designed with steps on the downstream side, for the purpose of breaking up and safely conducting the overflowing water down the face of the dam to the spillway channel below. There will be a cut-off wall about 20 ft. deep and 20 ft. wide under the foundation. Dovetailed contraction joints with a continuous vertical copper strip water stop extend across the dam from the foundation up at intervals of about 80 ft. All the masonry will be concrete, into which stones may be embedded in the sizes and proportions found practicable. All exposed surfaces are to be of selected native sandstone with mortar joints. The earth portion of the dam is of conventional design, with masonry corewall and with heavy rock paving on the upstream slope.

The spillway channel, along the toe of the dam, which will discharge waste waters into Schoharie Creek below, is about 80 ft. wide at the upper end and 300 ft. at the lower. The rock bottom slopes rather steeply and will be protected where necessary with masonry and substantial paving. The side of the channel away from the dam will be defined by a masonry retaining wall. A field model of the overfall section and channel is now being constructed by the engineers to determine certain details necessary to control the overflow.

The contract also includes the construction of about three miles of highways which must be completed before active operations on the dam can begin.

The stream-control scheme during construction, outlined in the contract, is similar to that used at Ashokan dam, involving the placing of, first, two large steel pipes over the foundation cut-off trench, and later, the construction of an arched opening through the dam 45 ft. wide by 50 ft. high, which will be filled with concrete when the dam is completed. This opening will have an appreciable bell-mouth to increase its flood capacity. Experience at Ashokan demonstrated the desirability of this increase in capacity. There is also a permanent blow-off, with 30-in. valve

in duplicate. The principal items of the contract are 396 000 cu. yd. of earth excavation, 92 500 cu. yd. of rock excavation, 617 000 cu. yd. of refilling and embanking, 436 000 cu. yd. of masonry, and 480 000 barrels of Portland cement. The contract time is sixty-six months.

The Shandaken Tunnel.

Contract 200, for the Shandaken tunnel, was awarded November 9, 1917, to the Degnon Contracting Company of New York City, for $12 138 738, based on contract quantities and unit prices. As this is an unusually long tunnel, it was considered advisable to divide the work into two parts, upon which intending bidders might submit their proposals separately; but the low bid accepted for the entire tunnel was less than the sum of the separate part bids received. The main parts of the contract comprise the intake works, the tunnel and the outlet works.

The intake works will be located about three miles north of the village of Prattsville and two miles south of the dam on the westerly side of the reservoir. They will consist of an intake channel and chamber with superstructure and intake shaft. The chamber will be built into the rock and will house eight 3-ft. by 7-ft. sluice gates set radially in the wall of the central well or extension of the intake shaft. The superstructure will have rubble walls of native bluestone, reinforced concrete floors, steel roof trusses and steel framing for the crane over the intake shaft. This building will have two wings, providing living quarters, garage, office, machine shop, and storerooms. The intake shaft will be 14 ft. in diameter, except where constricted near the top by a Venturi meter.

The tunnel extending from the intake works in a general southeasterly direction for a distance of 18 miles to the outlet works, to be located on the upper reaches of the Esopus Creek just south of the village of Allaben, will be of sufficient size and gradient to transport water from Schoharie reservoir to the upper reaches of Esopus Creek at the rate of 600 million gallons a day. The velocity of the flowing water will be 8.7 ft. per second, equal 5.9 miles per hour, acting as a grade tunnel. The tunnel will be operated intermittently at varying rates, depending on the condi-

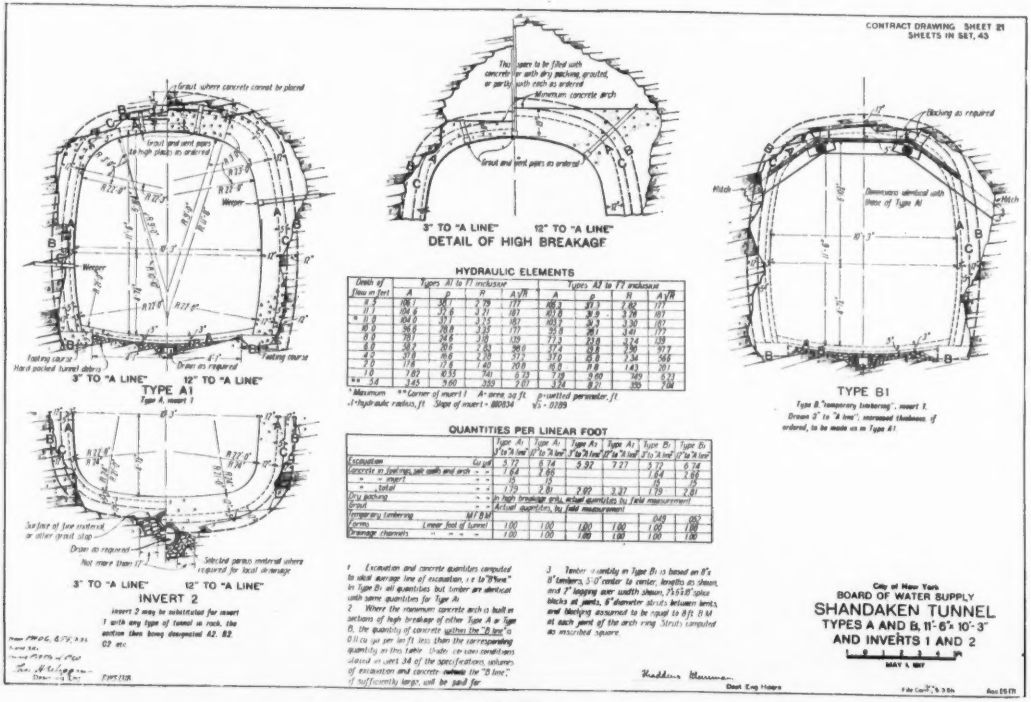

CONTRACT DRAWING SHEET 21
SHEETS IN SET, 43
3" TO "A LINE" 12" TO "A LINE"
TYPE A1
Type A, insert 1
3" TO "A LINE" 12" TO "A LINE"
INVERT 2
3" TO "A LINE" 12" TO "A LINE"
DETAIL OF HIGH BREAKAGE
TYPE B1
Type B, "temporary timbering", insert 1.
HYDRAULIC ELEMENTS
QUANTITIES PER LINEAR FOOT
City of New York
BOARD OF WATER SUPPLY
SHANDAKEN TUNNEL
TYPES A AND B, 11'-6" x 10'-3"
AND INVERTS 1 AND 2
MAY 1, 1917

FIG. 14.

tions of stream flow and storage. The intake sill will be at elevation 1 050, and the outlet channel weir will be at elevation 969. The tunnel will be in rock of shale or sandstone, except for about 350 ft. of tunnel in earth adjoining the outlet, and will be lined throughout with concrete. The waterway section is of horseshoe shape, 11 ft. 6 in. high by 10 ft. 3 in. wide, inside dimensions; about 5.7 cu. yd. of excavation per linear foot, and the tunnel will have a uniform grade of 4.4 ft. per mile except for the northerly 3½ miles, which will be depressed in order to pass in rock of good quality beneath the gorge of the Bear Kill. There are seven intermediate shafts which will be permanent in order to provide ready access to the tunnel. The shafts will be lined with concrete and will have a diameter of 14 ft. inside. Small superstructures of native stone will cap each shaft, and guarded openings in the floor and walls of these buildings will provide for air movements in the tunnel. The aggregate depth of shafts will be 3 238 lin. ft., the maximum depth of a single shaft being 630 ft. The minimum distance between shafts is 1.3 miles, the maximum 2.7 miles. The greatest depth of cover is where the tunnel passes under the main divide of the Shandaken Mountains, where the top of the mountain is 2 200 ft. above the tunnel. Work has been going on since the award of the contract, and to July 16, 1919, about 2 800 lin. ft., or 86 per cent. of the total depth of shafts, has been excavated; and 2 560 lin. ft., or 79 per cent. of the aggregate depth of shafts, lined with concrete, the lining being placed in stretches following the excavation. Three of the shafts have reached tunnel grade, and the others, except the intake shaft, are nearing it. The maximum weekly progress of shaft excavation in each of the seven shafts has been between 27 and 42 lin. ft., and the average progress of all shafts 12 ft. per week.

The outlet works at Allaben on Esopus Creek will be located 11 miles above the Ashokan reservoir, or 16 miles above the Ashokan dam. They will consist of about 500 ft. of aqueduct of the cut-and-cover type, an outlet chamber and about 290 ft. of open outlet channel. The cut-and-cover aqueduct will be of horseshoe shape, 11 ft. 6 in. high by 10 ft. 3 in. wide. Near the lower end it becomes a reinforced concrete waterway 11 ft. 6 in. in diameter, with a fall of 16½ ft., providing a water seal for the tunnel outlet.

The outlet chamber will be an open flaring structure whose invert will slope upward to the invert, elevation 969, of the open channel. The latter will have masonry sidewalls and local stone paving. Sloping gently for 290 ft. and passing under a steel girder bridge, which will carry the highway, the channel will discharge the water from the tunnel into Esopus Creek on its way to Ashokan reservoir.

The estimated contract quantities are about 600 000 cu. yd. of rock excavation, 100 000 cu. yd. of earth excavation, 200 000 cu. yd. of concrete masonry and 445 000 barrels of Portland cement. The contract provides direct payment for medical services for the laborers and sanitary services for the camps and working locations. The shaft work has been done with individual plants at each location, but a power line is being constructed by the contractor to bring electric energy from Kingston for the tunnel work. Within seventy-eight calendar months the work underground must be completed so that the tunnel can be operated, and all work must be completed within seven years.

Highways and Miscellaneous.

Contract 202, for the grading about $7\frac{3}{4}$ miles of highways around the Schoharie reservoir, was awarded on June 13, 1919, to the Schunnemunk Construction Company, Highland Mills, N. Y., for $176 000, based on the contract quantities and unit prices.

The estimated quantities are 112 500 cu. yd. of earth and rock excavation, 7 550 cu. yd. of paving, masonry, etc., 6 500 barrels of Portland cement, and 22 000 lin. ft. of wooden guard-rail. The contract time is eighteen months.

Other Schoharie work not yet under contract will be a permanent highway bridge over Schoharie Creek below the dam, a highway bridge and approaches over the Manorkill, a tributary of the reservoir, and the clearing of the reservoir site. To finish the main aqueduct to the city, additional tubes at fourteen locations, of steel-pipe siphons, will be required.

STATISTICS OF ASHOKAN, SCHOHARIE, AND KENSICO RESERVOIRS.

	Ashokan Storage Reservoir.	Schoharie Storage Reservoir.	Kensico Emergency Reservoir.
Capacity, total	130 000 000 000 gal.	22 000 000 000 gal.	38 000 000 000 gal.
Capacity, available	128 000 000 000 gal.	20 000 00 0000 gal.	29 000 000 000 gal.
Water surface	12.8 sq. miles = 8 180 acres	1.83 sq. miles = 1 170 acres	3.5 sq. miles = 2 218 acres
Land acquired	23.8 sq. miles = 15 222 acres	3.72 sq. miles = 2 372 acres	7.0 sq. miles = 4 500 acres
Elevation of top of dam, above tide	610 ft.	1 130 ft.	370 ft.
Elevation of flow line, above tide	West Basin, 590 ft. East Basin, 587 ft.	.....	.....
Length of reservoir	12 miles	1 130 ft.	355 ft.
Length of shore line	40 miles	5 miles	4 miles
Length of dams and dikes	5½ miles	12 miles	30 miles
Main dam:		2 300 ft.	3 300 ft.
Total length	4 650 ft.	2 300 ft.	1 825 ft.
Length of masonry portion	1 000 ft.	1 300 ft.	1 825 ft.
Height (maximum)	252 ft.	160 ft.	307 ft.
Thickness at base (maximum)	190 ft.	165 ft.	235 ft.
Thickness at top (minimum)	23 ft.	15 ft.	28 ft.
Width of reservoir:			
Maximum	3 miles	4/5 mile	3 miles
Average	1 mile	2/5 mile	1 mile
Depth of reservoir:			
Maximum	190 ft.	140 ft.	155 ft.
Average	50 ft.	58 ft.	52 ft.
Villages submerged	7	1	1
Permanent population of submerged area at beginning of work	2 000	350	500
Cemeteries removed	32	7	None
Bodies reinterred	2 800	1 330	None
Railroad relocated	11 miles	None	None
Highways discontinued	64 miles	13.6 miles	14.8 miles
Highways built	40 miles	12.4 miles	15.1 miles
Highway bridges built	10	2	4
Earth and rock excavation	2 500 000 cu. yd.	488 500 cu. yd.	1 400 000 cu. yd.
Embankment	7 300 000 cu. yd.	617 000 cu. yd.	2 010 000 cu. yd.
Masonry	900 000 cu. yd.	436 000 cu. yd.	965 000 cu. yd.
Cement	1 200 000 barrels	480 000 barrels	897 000 barrels
Maximum number of men employed	3 000	.....	1 500

PROTECTING IRON AND STEEL STANDPIPES FROM CORROSION.

BY CHARLES W. SHERMAN.*

The proper maintenance of an iron or steel standpipe involves periodic painting to prevent corrosion which would weaken and ultimately destroy the structure. The protection of the exterior surface involves no particular difficulty, as it can be inspected at any time, and the coating can be replaced whenever it may appear necessary or desirable. A paint coating on the outside surface of the standpipe is subject to practically the same conditions as one on a bridge or building. The interior surface is, however, difficult to protect, being constantly in contact with water. Moreover, it can be inspected only at intervals and with some difficulty, and it is often difficult or impossible to leave the standpipe empty for a sufficiently long period to clean and paint the surface in the most desirable way.

The durability of a protective coating on the interior surface of a standpipe is dependent not only on the qualities of the coating itself, but also on the character of the plates to which the coating is applied (whether wrought iron or steel); the cleanness, dryness, and temperature of the surface when the coating is applied; the character of workmanship; the character of the water; the amount of ice formation in winter; fluctuations in the water level, etc.

Data relative to the conditions existing when coatings were applied have comparatively seldom been made a matter of record. Indeed, it is more often than not the case that the kind of paint and the quantity used are not recorded. Consequently, the amount of definite information obtainable, even by extended inquiry, is comparatively limited, and much of it is of doubtful value.

* Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

Place.	Date of Construction.	Material.	Dimensions. Diam. Ft.	Height. Ft.	Enclosing Tower.	Roof.	Character of Water.
Amityville, N. Y.	1892	Iron	20	125	No	No	Ground
Asbury Park, N. Y.	1888	Iron	12	125	No	No	Ground
Atlantic City, N. J.	1882	Iron	25	132	No	No	Ground and surface; soft
Atlantic City, N. J.	1888	Iron	15	140	No	No	Ground and surface; soft
Baldwinsville, N. Y.	1889	Iron	20	50	No	No	Ground; hard
Baltimore, Md.							
Roland	1905	Steel	24	92.5	Yes	Yes	Surface; soft; filtered and al
Arlington	1898	Steel	25	95	Yes	Yes	Surface; soft; filtered and al
Bangor, Me.	1896	Steel	75	50	Yes	Yes	Filtered and alum
Barnegat, N. J.	1909	Steel	20	20	Yes	Yes	Artesian; soft
Belfast, Me.	1887	Iron	30	45	No	No	Filter and soda and alum
Belmar, N. J.	1908	Iron	18	125	No	No	Artesian; soft
Biddeford, Me.	1906	Steel	60	50	No	No	Soft; filtered and alum
Billerica, Mass.	1898	Iron	25	118	No	Yes	.....
Boston (Metrop. W. W.)							
Forbes Hill	1902	Steel	30	64.3	Yes	Yes	Surface; soft
Arlington	1894	Iron	40	60	No	Yes	Surface; soft
Bellevue	1914	Steel	100	44.3	Yes	Yes	Surface; soft
Brewer, Me.	1904	Steel	30	100	No	No	Surface; sand filter
Bridgton, Me.	1903	Steel	35	55	No	No	Soft
Bristol, Conn.	1901	Steel	30	35	No	No	Surface; soft
Bristol, R. I.	1908	Steel	40	50	No	Yes	Ground; filtered and alum a
Brockport, N. Y.	abt. 1891	Steel	20	75	No	No	Ground; hard
Brockton, Mass.	1890	Iron?	62	60	No	No	.....
Brookville, Pa.	2 abt. 1894	Steel?	20	24	Yes	No	Surface; filtered and alum and
	2, 1902	Steel	20	24	Yes	No	Surface; filtered and alum and
Burlington, N. J.	1887	Iron	20	120	No	No	River, filtered and alum and
Canton, N. Y.	1889	Steel	20	72	No	No	Surface; soft
Cape May	1902	Steel	25	135	No	Yes	Artesian; hard
Carthage, N. Y.	1887	Iron	25	75	No	No	Soft; spring
Circleville, Ohio	1886	Iron	22	150	No	No	Hard
Conneaut, Ohio	1888	Iron	20	120	No	No	Soft; filtered; sulph.; alu
Cortland, N. Y.	1911	Ingot iron	60	50	No	No	Hard
Dayton, Ohio	1916	Steel	42	90	No	Yes	Ground; hard
	1913	Steel	41	85	No	Yes	Ground; hard
Delaware, Ohio	1888	Iron	20	100	No	No	Ground; med.
Duluth, Minn.	1913	Steel	22	27	No	Yes	Ground; soft
	1914	Steel	22	27	No	Yes	Surface; soft; hypo.
Eagles Mere, Pa.	1902	Steel	11-5/12	100	No	Yes	Surface; soft
Elmer, N. J.	1912	Steel	12	110	No	No	Soft; "best in state"
Exeter, N. H.	1886	.....	25	60	.....	.....	.....
Fairport, N. Y.	1893	Steel	26	75	No	No	Hard
Fall River, Mass.	?	.....	3 (65 x 56) 1 (73 x 37)		No	No	Med.; surface
	1886	Iron	73 x 34		.....	.....	.....
	1892	.....	65 x 56		.....	.....	.....
Falmouth, Mass.	1903	Iron	35	30	No	Yes	Surface; soft
	1892	Iron	20	85	No	No	Surface; soft
Fostoria, Ohio	1891	Steel	25	100	Yes	No	Surface; soft; filtered
Foxborough, Mass.	1891	Iron	20	125	No	Yes	Ground
Framingham, Mass.	1890±	.....	40	81	No	Yes	Mixed
Franklin, Mass.	1886	Iron	37	80	No	No	Ground; hard
Grand Rapids, Mich.	1907	Steel	50	60	Yes	Yes	Filtered; alum and hy
Hamilton, N. Y.	1895	Iron	30	38	Yes	.....	Ground; med.; filtered
Highlands, N. J.	1907	Steel	30	30	No	No	Soft; filtered

REPORTS ON PAINTING THE INTERIOR SURFACE OF STANDPIPE. Part 1.

r.	Date When Painted. (Interior.)	Preparation of Surface.	No. of Coats.	Kind of Paint.	Amount and Cost, Including Applying.	Condition of Standpipe.
	1892	.....	2	.....	.....	.....
	1914 (50 ft. down from top)	Wire brushed	1	Graphite	.....	.....
	1916	Scraped and brushed	2	Dixon's graphite	53 gal., $200	.....
e; soft	1905	Scraped and wire brushed	2	Mineral rubber	.....	Good, but needs painting (will be done 1917).
e; soft	1905	Scraped and wire brushed	2	Mineral rubber	.....	do.
	1889	Scraped and wire brushed	1	Graphite	.....	.....
	1914	Scraped and wire brushed	1	Graphite	10 gal., $20	.....
and alum	1912	Wire brushed	.....	.....	$195	.....
and alum	1912	Wire brushed	.....	.....	$315	.....
m	1896 and each 4 years	Wire brushed	2	Harrison's Antoxide	76 gal., $369	.....
	1914	Scraped	1	"Hot dressing"	$100	.....
lum	1887	.....	3	Asphalt	.....	.....
	1903	.....	2	Graphite elast.	.....	Very badly rusted on lower sheets.
	(1911) should be painted	.....	.....	.....	.....	.....
	1908	.....	2	"Ordinary"	25 gal.	.....
	1916	Wire brushed	2	Red lead and B. oil	25 gal. (650 lbs. red lead), $550	.....
alum	1912	Scraped and wire brushed	.....	Graphite	.....	.....
	1916	.....	2	S & W metallistic	55 gal., $507*	.....
.....	1898	.....	.....	.....	.....	.....
	1901	.....	.....	.....	.....	.....
	1906	.....	2	Carb. coating	.....	.....
	1902	.....	1	Red lead	$427*	.....
			2	Gilsonite		
	1912	.....	3	Red lead	$430*	.....
	1906	.....	1	Red lead	$425*	.....
			2	Gilsonite		
	1911	Scraped and wire brushed	(Same)	(Same)	$475*	.....
	1915	Sand blasted	3	Red lead	.....	(See note, Rept. 1915, p. 50.)
ter	Every 4 years	.....	2	Smith's Durable metal coating	1 bbl. (labor, $75)	.....
	.....	.....	.....	.....	.....	Has not been painted since erection.
	1912	.....	.....	.....	Labor, $83; paint, $62 = $145	.....
um and soda	1908	.....	2	Asphalt	90 gal.	.....
	1915	Wire brushed	2	Dixon's graphite	65 gal., $205*	.....
.....	1904	Scraped and wire brushed	1	Asphalt	30 gal., $90	.....
	1908	Scraped and wire brushed	1	Asphalt	30 gal., $95	.....
n and hypo.	Not since erection?	.....	.....	.....	.....	.....
n and hypo.	Not since erection?	.....	.....	.....	.....	.....
and hypo.	Every 2 years, 1915	Scraped and wire brushed	2	Red lead in oil	$300 +*	.....
	Do not paint interior	.....	.....	.....	.....	.....
	1905	.....	1	Cement wash	.....	.....
	1913	Scraped and wire brushed	1	Red lead in oil	.....	.....
	1916	Scraped and wire brushed	1	Red lead in oil	.....	Condition fair before painting.
	1898	Wire brushed	1	Graphite	$100*	.....
	1908	Wire brushed	1	Graphite	$125*	.....
; alum	No record of interior paint	.....	.....	.....	.....	Not known to present authorities. Outside 1888, 1902, 1915, 1916; 1 coat each time.
	1911	.....	2	Sherwin-Williams	.....	.....
	1914	Wire brushed	1	Dixon's graphite	40 gal. paint, $60; labor, $37	.....
	.....	.....	.....	Lowe Bros. Iron Shield	.....	Good work.
	1913	.....	3	.....	.....	.....
	1917	.....	2	Lowe Bros. Iron Shield	.....	.....
	1885?	.....	2	Dixon's graphite	.....	.....
	1914	Scraped and wire brushed	2	Goheen carbon coating	25 gal., $150	.....
	1913	.....	1	Red lead (shop)	.....	.....
			1	Graphite (field)		
o.	1914	.....	(Same)	(Same)	.....	.....
	About every 3 years	Scraped and wire brushed	1	Dixon's graphite	15 gal., $100	Operated summer only; drained in winter.
e"	1915	Scraped	1	Asbestos	52 gal., $90	.....
.....	1886	.....	3	Asphalt	.....	.....
	1895	.....	1	Asphalt	.....	Lower rings quite badly rusted.
	1902	.....	2	D. M. C.	53 gal., $178*	Rusted and lower rings quite badly pitted.
	1907	.....	2	Chrysolite	.....	.....
	(Rept. 1911)	.....	.....	.....	.....	.....
	1906	.....	1	Graphite	.....	No other record.
	1913	.....	1	Graphite	$70*	.....
	1914, 4 tanks	Scraped and wire brushed	2	Det. graphite	$1,296†	.....
.....	1886	.....	3	Asphalt	.....	.....
	1889	.....	.....	.....	.....	.....
	1893	.....	.....	.....	.....	.....
	1897	.....	.....	Asphalt	.....	.....
	1900	.....	.....	.....	.....	.....
	1903	.....	.....	.....	.....	.....
.....	1892	.....	.....	.....	.....	.....
	1897	.....	.....	Asphalt	.....	.....
	1898	.....	.....	.....	.....	.....
	1900	.....	.....	.....	.....	.....
	1902	.....	.....	Graphite	.....	.....
	1903	.....	.....	.....	.....	.....
	1908	Sand blast	.....	.....	.....	.....
	1915‖	.....	1	Lucas Metalife	26 gal., $68.50*	.....
	1916	.....	1	Lucas Metalife	16 gal., $144*	.....
d	Every 2 years (1916)	Scraped and wire brushed	1	Asphalt	30 gal., $60	.....
	1916	.....	2	Det. graphite	$165	.....
	1911	.....	.....	.....	Total, $300	.....
	1910	.....	2	Graphite	40 gal.	.....
	1916	Washed with turpentine, scraped and wire brushed	2	Dixon's graphite	40 gal., $200*	.....
hypo.	1915	Scraped and wire brushed	1	Patterson-Sargent Co.'s no-Croc	.....	.....
			1	Patterson-Sargent Co.'s gas-holder black	.....	.....
ered	1895	.....	.....	.....	.....	No data on kind, costs, etc.
	1912	Scraped	2	Asphalt	.....	.....
	1913		(2–1)	Asphalt	65 gal., $299	.....

Elmira, N. Y.	1912	Steel	12	110	No	No	Soft; "best in state"
Exeter, N. H.	1886	.....	25	60	.....	.....	.....
Fairport, N. Y.	1893	Steel	26	75	No	No	Hard
Fall River, Mass.	?	.....	3 (65 x 56) 1 (73 x 37)		No	No	Med.; surface
	1886	Iron	73 x 34		.....	.....	.....
	1892	.....	65 x 56		.....	.....	.....
Falmouth, Mass.	1903	Iron	35	30	No	Yes	Surface; soft
	1892	Iron	20	85	No	No	Surface; soft
Fostoria, Ohio	1891	Steel	25	100	Yes	No	Surface; soft; filtered
Foxborough, Mass.	1891	Iron	20	125	No	Yes	Ground
Framingham, Mass.	1890	.....	40	81	No	Yes	Mixed
Franklin, Mass.	1886	Iron	37	80	No	No	Ground; hard
Grand Rapids, Mich.	1907	Steel	50	60	Yes	Yes	Filtered; alum and hypo.
Hamilton, N. Y.	1895	Iron	30	38	Yes	.....	Ground; med.; filtered
Highlands, N. J.	1907	Steel	30	30	No	No	Soft; filtered
Hingham, Mass.	1883	Iron	40	57	No	Yes	.....
	1912	Steel	20	75	No	No	.....
Hyannis, Mass.	1912	Steel	25	100	No	Yes	Ground; soft
Jackson, Ohio	1900	Iron	30	50	No	No	Ground
Jamesburg, N. J.	1909	Steel?	16	65	No	No	.....
Jenkintown, Pa.	1907	Wrought Iron?	28	127	No	Yes	.....
	1912	Wrought iron?	60	65	No	Yes	Filtered and alum and hypo.
Knoxville, Tenn.	1894	Steel	32	85	.....	.....	.....
Lancaster, Pa.	?	Steel	25	110	No	Yes	Filtered; chlorine and alum
Lewisburg, Pa.	1883	Iron	12	130	.....	.....	.....
	1897	Iron	15	130	.....	.....	.....
Louisville, Ky.	1907	Steel	50	105	.....	.....	.....
			4.33	115	No	Yes	Surface; filtered; chlorine and alum
Manchester, Mass.	1892	.....	35	75	.....	Yes	.....
Marion, Mass.	1907	.....	20	100	.....	.....	.....
Marlboro, Mass. (to 1912 only)	1895	Iron	30	35	No	Yes	Surface
Matawan, N. J.	1903	Steel	12	115	No	Yes	Soft; filtered
Mattapoisett, Mass.	1913	Iron (?)	25	90	No	Yes	Ground; soft
Medford, N. J.	1893	Iron	12	100	No	No	.....
Media, Pa.	1898	Iron	35	35	No	No	Surface; soft; filtered; cl., alum
Merrimac, Mass.	1904	.....	40	45	.....	Yes	.....
Middleboro, Mass.	1885	Iron	20	103	No	Yes	.....
Millis, Mass.	1891	Iron	20?	100	No	No	Hard
Millville, N. J.	1878	Iron	12	128	No	No	.....
Milwaukee, Wis.	1886	Steel?	15	173	Yes	No	Surface; hard; cl.
	1874	Steel?	4	125	Yes	No	Surface; hard; cl.
Minneapolis, Minn.	1910	Steel	26	55	Yes	Yes	River; hard; filtered; cl.; alum
	1893	Steel	22	45	Yes	Yes	.....
Montclair, N. J.	1887	Steel	40	30	No	No	Alum; chlorine

* Includes outside.

† No

Repair every 3 years	Scraped and wire brushed	1	Dixon's graphite	15 gal., $100	Operated summer only; drained in winter.
1915	Scraped	1	Asbestos	52 gal., $90	.....
1886	.....	3	Asphalt	.....	.....
1895	.....	1	Asphalt	.....	Lower rings quite badly rusted.
1902	.....	2	D. M. C.	53 gal., $178*	Rusted and lower rings quite badly pitted.
1907	.....	2	Chrysolite	.....	.....
(Rept. 1911)	.....	.....	.....	.....	.....
1906	.....	1	Graphite	.....	No other record.
1913	.....	1	Graphite	$70*	.....
1914, 4 tanks	Scraped and wire brushed	2	Det. graphite	$1,296†	.....
1886	.....	3	Asphalt	.....	.....
1889	.....	.....	.....	.....	.....
1893	.....	.....	.....	.....	.....
1897	.....	.....	Asphalt	.....	.....
1900	.....	.....	.....	.....	.....
1903	.....	.....	.....	.....	.....
1892	.....	.....	.....	.....	.....
1897	.....	.....	Asphalt	.....	.....
1898	.....	.....	.....	.....	.....
1900	.....	.....	.....	.....	.....
1902	.....	.....	Graphite	.....	.....
1903	.....	.....	.....	.....	.....
1908	Sand blast	.....	.....	.....	.....
1915‖	.....	1	Lucas Metalife	26 gal., $68.50*	.....
1916	.....	1	Lucas Metalife	16 gal., $144*	.....
Every 2 years (1916)	Scraped and wire brushed	1	Asphalt	30 gal., $60	.....
1916	.....	2	Det. graphite	$165	.....
1911	.....	.....	.....	Total, $300	.....
1910	.....	2	Graphite	40 gal.	.....
1916	Washed with turpentine, scraped and wire brushed	2	Dixon's graphite	40 gal., $200*	.....
1915	Scraped and wire brushed	1	Patterson-Sargent Co.'s no-Croc	.....	.....
		1	Patterson-Sargent Co.'s gas-holder black	.....	.....
1895	.....	.....	.....	.....	No data on kind, costs, etc.
1912	Scraped	2	Asphalt	.....	.....
1913	.....	(2–1)	Asphalt	65 gal., $299	.....
1915	Scraped and wire brushed	2	Red lead (Met. W. Bd.)	35 gal., $548†	.....
1912	.....	2	"Patent"	.....	.....
1915	Scraped	2	Red lead, interior	About $100*	"Very little signs of original paint."
		2	Graphite, exterior		
.....	.....	.....	.....	.....	Never painted since built. Cleaned about every 2 years. Not badly corroded.
1912	Scraped and brushed	.....	Dixon's graphite	.....	.....
1908	Cleaned and dried	1	Main's hot coating	.....	"Looks as good to-day as it did the day it was put on; there is no limit to wear."
1912	Cleaned and dried	1	Main's hot coating	.....	
1894	.....	.....	.....	.....	.....
1900	.....	.....	Various	.....	.....
1904	Thoroughly cleaned	2	Graphite	72 gal., $145	.....
1911	Thoroughly cleaned and scraped	2	Graphite	85 gal., $165	.....
1915	Cleaned with wire brush	1	Graphite	39 gal., $186	.....
1911	Heavy brush	1	Red lead	$190	.....
.....	.....	.....	.....	.....	.....
1907	Wire brushed	2	?	.....	.....
1892	.....	.....	.....	.....	.....
1894	.....	.....	Ebonized varnish	.....	.....
1907	.....	.....	.....	.....	.....
1911	.....	.....	.....	$472*	.....
1895	.....	2	Asphalt	.....	All gone in 3 years.
1898	.....	2	Paint	.....	All gone in 3 years.
1902	.....	2	Paint (another kind)	.....	Hanging in shreds in 3 years.
1905	.....	2	Paint (still another kind)	.....	All gone in 4 years. No traces left.
1909	.....	.....	.....	.....	.....
1912	.....	1	Red lead	.....	.....
		2	"Paint"	.....	
.....	Scraped	.....	Dixon's graphite	.....	Interior painted but once since built.
1913	.....	2	?	.....	.....
1914	.....	?	Dixon's graphite	.....	.....
1909	Scraped and wire brushed	2	Dixon's graphite	35 gal., $75	.....
1916	Scraped and wire brushed	2	Dixon's graphite	30 gal., $127	.....
1904	.....	.....	.....	.....	.....
1905	.....	.....	.....	.....	.....
1906	.....	.....	.....	.....	.....
1910	.....	.....	.....	.....	.....
1885	Thorough scraping	2	Asphalt locally made	.....	Painted every 2 or 3 years. Metal well protected (standpipe taken down 1915).
1888					
1892					
1896					
1901					
1905					
1909					
1911					
1909	Scraped	1	Graphite	.....	.....
1912	Scraped	1	Graphite	.....	.....
.....	.....	.....	.....	.....	Do not know.
.....	.....	.....	.....	.....	"Interior not painted. Standpipe in excellent condition."
.....	.....	.....	.....	.....	do.
1915	Scraped	1	Red lead	.....	.....
1916	Scraped	2	Red lead	.....	Not painted between '93 and '16. Old paint gone; metal badly pitted.
1897	Scraped and wire brushed	.....	Asphalt	35 gal., $27	.....
1902	Scraped and wire brushed	.....	Harrison's T. & C. 106	25 gal., $20	.....
1906	Scraped and wire brushed	.....	Dixon's graphite	25 gal.	.....

† Not including paint.

‖ Painted every two years.

Place.	Date of Construction.	Material.	Dimensions. Diam. Ft.	Dimensions. Height. Ft.	Enclosing Tower.	Roof.	Character of Water.
Nantucket, Mass.	1878	Iron	24	15	No	No	Surface; soft
	1908	Steel	30	80	No	No	.....
Narragansett Pier, R. I.	1888	Iron	30	70	No	No	Surface; soft
Needham, Mass.	1891	Iron	25	85	No	Yes	.....
New London, Conn.	1889	Iron	25	26	No	No	Surface; soft
New York City — Richmond Borough	1911	Steel	20	100	No	No	Ground; hard
	1897	Steel	20	60	No	No	Ground; hard
North Attleboro, Mass.	1884	Iron	40	60	No	Yes	Ground; soft
Norwood, Ohio	1884	Iron	40	60	No	Yes	Artesian
Oak Bluffs, Mass.	1890	Iron	20	70	.....	.....	.....
Old Orchard, Me.	1909	Steel	33	105	No	No	Soft; filtered; alum
Onset, Mass.	1894	Steel	20	40	No	No	Surface; soft
Ossining, N. Y.	1889	Iron	24	30	Yes	Yes	Surface; soft; cl.
Palatka, Fla.	1887	.....	25	50	.....	.....	.....
Paris, Ky.	1891	.....	25	80	.....	.....	.....
Perry, N. Y.	1895	Steel	15	75	No	Yes	Lake; soft
Philadelphia, Pa.	1900	Steel	11	150	No	No	River; filt.; cl.
	1882	Iron	5	153	No	No	River; filt.; cl.
	1900	Steel	11	150	No	No	River; filt.; cl.
Plainville, Mass.	1909	Steel	25	67.3	No	Yes	Ground; hard
Portland, Me. (3 standpipes)	.....	.....	.....	.....	.....	.....	.....
Portland, Ore.	[illegible]9	Steel	16	40	No	No	Surface; soft
	¶1890	Iron?	25	100	No	No	Surface; soft
	1912	Steel	18	61	No	No	Surface; soft
Putnam, Conn.	1885	Iron	30	45	No	No	Surface; soft; filtered
Rahway, N. J.	1906	Steel	25	125	No	No	Surface; soft; filtered and and chlorine
Reading, Mass.	1890	Iron	30	100	No	Yes	Ground; hard; filtered; lime
Rockville, Conn.	1899	Steel	30	60	No	No	Ground; soft
Rutland, Mass.	1896	Iron	20	90	No	No	Surface; soft
St. Louis, Mo.	1868–70	Iron	5	160	Yes	Yes	Surface
	1886	Iron	6	160	Yes	Yes	Surface; filtered; lime; sulph. cl.
	1898	Steel	6	140	Yes	Yes	do.
	1908	Steel	30	34.8	No	Yes	do.
Seattle, Wash. (3 standpipes; 2 enclosed)	.....	.....	.....	.....	.....	.....	.....
Seneca Falls, N. Y.	1896	Iron and Steel	30	100	No	No	Surface; hard; filtered; al

Y OF REPORTS ON PAINTING THE INTERIOR SURFACE OF STANDPIPE. Part 2.

Water.	Date When Painted. (Interior.)	Preparation of Surface.	No. of Coats.	Kind of Paint.	Amount and Cost, Including Applying.	Condition of Standpipe.
soft	.....	Scraped and wire brushed each time	.....	Various asphalt variations and hot Alcatraz asphalt §	.....	18 times between 1878 and 1906; 1 to 2-year intervals. Used Prince's Mineral Brown. Taken down in 1909.
.....	1908	.....	2	Met. P. & W. Co. graph. elast. No. 1	50 gal.	About all gone in 8 years.
	1916	.....	1	Bit. mixture put on boiling hot over layers of asphalt varnish	14 bbl.	.....
soft	1888 new	.....	.....	.....	.....	.....
	?	Light brushing	1	Graphite	.....	.....
	?	Light brushing	1	Asphalt	.....	.....
	1914	Scraped and wire brushed	1	Asphalt	$375	.....
.....	.....	.....	.....	.....	.....	Not painted inside since original construction.
oft	1897	.....	2	Asphalt	30 gal., $90	.....
	1903	.....	?	Graphite	53 gal., $102	.....
	1909	Wire brushed	.....	Graphite	10 gal., $73	.....
	1912	Wire brushed	.....	.....	$99	.....
ard	1911	.....	3	Red lead	.....	Painted when erected.
ard	1911	Scraped and wire brushed	1	Red lead	.....	.....
			1	Graphite	.....	.....
oft	.....	.....	2	Det. Gr. No. 501 " Hyd. priming " and No. 106 " Hyd. priming "	30 gal. each	Every 3 years. About 7 years ago inside was sand blasted ($1,250), having been neglected some years previously. Some bad pitting; cost labor applying 2 coats, inside and out, $200.
.....	.....	.....	.....	.....	.....	Never painted. " Paint not needed."
.....	1890	.....	3	Asphalt	.....	.....
	1894	.....	2	Asphalt	.....	Paint mostly gone.
	1900	.....	2	D.M.C. on one half;	.....	Paint mostly gone.
			2	Kauri zinc paint on remainder		
	1907	.....	2	Chrysolite	31 gal.	D.M.C. all gone on 5 lowest rings; zinc paint on some; gone on others.
	1911	.....	2	Creolastic black	.....	.....
alum	1912	Scraped and wire brushed	.....	Graphite	.....	.....
	1916	Scraped and wire brushed	2	S. & W. metallistic	45 gal., $382*	.....
ft	1894	.....	2	Iron metallic paint	10–12 gal.	Not durable.
	1913	Scraped and wire brushed	2	Graphite (" metallistic ")	$200	.....
; cl.	1907	Scraped and wire brushed	1	Asphalt	About 20 gal.	Corrosion very slight; water leaves deposit which seems to protect metal.
.....	1881	.....	.....	.....	.....	.....
	1896	.....	2	P. & B. No. 2	30 gal.	Inside badly pitted.
	1898	.....	2	D.M.C.	30 gal.	Badly scaled.
	1902	.....	2	D.M.C.	33 gal.	Paint entirely gone.
	1911	.....	2	Creolastic	.....	.....
.....	1891	.....	3	Asphalt	.....	.....
	1905	.....	2	Chrysolite	35 gal.	.....
	1900	Scraped	2	Graphite	1 bbl.	.....
	1905	.....	2	Graphite	.....	.....
	1909	.....	2	Graphite	.....	.....
	1912	.....	2	Graphite	.....	Should have been painted this year (1916).
cl.	1900	.....	1	Red lead	.....	.....
			2	Dixon's graphite	.....	.....
cl.	1882	.....	3	Lead paint	.....	.....
cl.	1900	.....	3	Lead paint	.....	.....
d	.....	.....	.....	.....	.....	Never painted since built. Expect to paint 1917.
.....	.....	.....	.....	.....	.....	All painted 1906, and expect to paint 1917.
	1909	.....	2	Ferrubron	.....	.....
	1914	.....	.....	.....	.....	Outside only.
t	1900	.....	.....	Red lead	.....	.....
	1906	Scraped and wire brushed	2	Ferrubron	.....	.....
	1912	.....	.....	.....	.....	Outside only.
	1912	.....	.....	Ferrubron	.....	.....
tered	1885	.....	3	Asphalt	.....	.....
	1893	.....	1	Asphalt	.....	.....
	1896	.....	1	Asphalt	.....	.....
	1905	Dried and scraped	2	Chrysolite	25 gal.	2 bottom sheets and part of third rusty, top sheets in poor shape.
l and alum	1906	.....	2	Dixon's sil. graphite	.....	Upper 30 feet.
e	1913	.....	1	Red lead	.....	.....
			1	Dixon's graphite	.....	.....
lime; alum	1895	Wire brushed	1	Government waterproof	$376*	.....
	1897	Wire brushed	1	Smith's D.M.C. coating	$450*	.....
	1901	Wire brushed	1	Smith's D.M.C. coating	$517*	.....
	1904	Wire brushed	1	Smith's D.M.C. coating	$616*	.....
	1909	Wire brushed	1	Smith's D.M.C. coating	$718*	.....
	1913	Wire brushed	2	Bitumastic enamel	$1 609*	.....
	1914	Wire brushed	1	Asphalt	$125*	.....
	1896	.....	.....	Red mineral paint	.....	Not painted since.
	.....	.....	.....	.....	.....	Not painted during its life. Abandoned 19 (?) Badly pitted at waterline only.
lph. ir., al.,	.....	.....	.....	.....	.....	Interior not painted; still in service; " corrosion negligible."
	1898	.....	2	Red lead	.....	.....
	1915	Scraped and wire brushed	2	Red lead	400 lb. lead.; 15 gal. oil, 5 gal. turp.	Badly corroded in spots. Generally protected by lime coating.
	1908	.....	2	Graphite	.....	.....
	1915	.....	.....	Red lead	.....	No paint left; very little corrosion; lime coating.
.....	.....	.....	1	Asphalt on inside	About 25c. per square yard	Paint about every 2 years.
; alum	1901	Scraped and wire brushed	2	.....	.....	Probably painted in 1917.
	1907					
	1911					

	1912	Steel	18	61	No	No	Surface; soft
Putnam, Conn.	1885	Iron	30	45	No	No	Surface; soft; filtered
Rahway, N. J.	1906	Steel	25	125	No	No	Surface; soft; filtered and alum and chlorine
Reading, Mass.	1890	Iron	30	100	No	Yes	Ground; hard; filtered; lime; alum
Rockville, Conn.	1899	Steel	30	60	No	No	Ground; soft
Rutland, Mass.	1896	Iron	20	90	No	No	Surface; soft
St. Louis, Mo.	1868–70	Iron	5	160	Yes	Yes	Surface
	1886	Iron	6	160	Yes	Yes	Surface; filtered; lime; sulph. ir., al., cl.
	1898	Steel	6	140	Yes	Yes	do.
	1908	Steel	30	34.8	No	Yes	do.
Seattle, Wash. (3 standpipes; 2 enclosed)							
Seneca Falls, N. Y.	1896	Iron and Steel	30	100	No	No	Surface; hard; filtered; alum
Sewickley, Pa.	1901	Steel	20	110	No	No	Surface; hard; hypo.
Sharpsville, Pa.	1900	Steel?	20	40	No	No	Hard
Spencer, Mass.	1899	Steel	40	39	No	No	Surface; soft
Spokane, Wash.	1904	Steel	30	70	No	No	Ground; hard
	1908	Steel	30	70	No	No	Ground; hard
Summit, N. J.	1907	Steel	12	75	No	No	Ground; hard
	1890	Iron	25	65	No	No	Ground; hard

	1906	Scraped and wire brushed	2	Ferrubron	.....	.....
	1912	.....	.....	.....	.....	Outside only.
	1912	.....	.....	Ferrubron	.....	.....
	1885	.....	3	Asphalt	.....	.....
	1893	.....	1	Asphalt	.....	.....
	1896	.....	1	Asphalt	.....	.....
	1905	Dried and scraped	2	Chrysolite	25 gal.	2 bottom sheets and part of third rusty, top sheets in poor shape.
lum	1906	.....	2	Dixon's sil. graphite	.....	Upper 30 feet.
	1913	.....	1	Red lead	.....	.....
			1	Dixon's graphite	.....	.....
um	1895	Wire brushed	1	Government waterproof	$376*	.....
	1897	Wire brushed	1	Smith's D.M.C. coating	$450*	.....
	1901	Wire brushed	1	Smith's D.M.C. coating	$517*	.....
	1904	Wire brushed	1	Smith's D.M.C. coating	$616*	.....
	1909	Wire brushed	1	Smith's D.M.C. coating	$718*	.....
	1913	Wire brushed	2	Bitumastic enamel	$1 609*	.....
	1914	Wire brushed	1	Asphalt	$125*	.....
	1896	.....	.....	Red mineral paint	.....	Not painted since.
	.....	.....	.....	.....	.....	Not painted during its life. Abandoned 19 (?) Badly pitted at waterline only.
, al.,	.....	.....	.....	.....	.....	Interior not painted; still in service; "corrosion negligible."
	1898	.....	2	Red lead	.....	.....
	1915	Scraped and wire brushed	2	Red lead	400 lb. lead.; 15 gal. oil, 5 gal. turp.	Badly corroded in spots. Generally protected by lime coating.
	1908	.....	2	Graphite	.....	.....
	1915	.....	.....	Red lead	.....	No paint left; very little corrosion; lime coating.
....	.....	.....	1	Asphalt on inside	About 25c. per square yard	Paint about every 2 years.
	1901	Scraped and wire brushed	2	.....	.....	Probably painted in 1917.
	1907					
	1911					
	1907	Brooms and wire brushed	1	Carbon coating	25 gal., $90	.....
	1911	.....	1	Carbon coating	30 gal., $100	
	1900	.....	1	.....	.....	Not painted inside since erection.
	1899	.....	1	.....	.....	.....
	1904	Wire brushed	1	Nat. P. & V. Co. graph. elast. paint	$68*	.....
	1912	Wire brushed	1	Nat. P. & V. Co. graph. elast. paint	$90	.....
	1904	Wire brushed	1	Asphalt	.....	.....
	1908	.....	1	.....	.....	.....
	1907	.....	2		.....	.....
	1914	Scraped and wire brushed	2	Hot coating similar to bitumastic	.....	.....
	[illegible]		[illegible]		.....	.....
	1894	Scraped and brushed	2	White lead	.....	.....
	1903	.....	2	Hot Asphalt	.....	.....

Place.	Date of Construction.	Material.	Dimensions. Diam. Ft.	Dimensions. Height. Ft.	Enclosing Tower.	Roof.	Character of Wa
Nantucket, Mass.	1878	Iron	24	15	No	No	Surface; soft
	1908	Steel	30	80	No	No	.....
Narragansett Pier, R. I.	1888	Iron	30	70	No	No	Surface; soft
Needham, Mass.	1891	Iron	25	85	No	Yes	.....
New London, Conn.	1889	Iron	25	26	No	No	Surface; soft
New York City — Richmond Borough	1911	Steel	20	100	No	No	Ground; hard
	1897	Steel	20	60	No	No	Ground; hard
North Attleboro, Mass.	1884	Iron	40	60	No	Yes	Ground; soft
Norwood, Ohio	1884	Iron	40	60	No	Yes	Artesian
Oak Bluffs, Mass.	1890	Iron	20	70	.....	.....	.....
Old Orchard, Me.	1909	Steel	33	105	No	No	Soft; filtered; a
Onset, Mass.	1894	Steel	20	40	No	No	Surface; soft
Ossining, N. Y.	1889	Iron	24	30	Yes	Yes	Surface; soft;
Palatka, Fla.	1887	.....	25	50	.....	.....	.....
Paris, Ky.	1891	.....	25	80	.....	.....	.....
Perry, N. Y.	1895	Steel	15	75	No	Yes	Lake; soft
Philadelphia, Pa.	1900	Steel	11	150	No	No	River; filt.;
	1882	Iron	5	153	No	No	River; filt.; c
	1900	Steel	11	150	No	No	River; filt.; c
Plainville, Mass.	1909	Steel	25	67.3	No	Yes	Ground; hard
Portland, Me. (3 standpipes)	.....	.....	.....	.....	.....	.....	.....
Portland, Ore.	[illegible]	Steel	16	40	No	No	Surface; soft
	1890	Iron?	25	100	No	No	Surface; soft
	1912	Steel	18	61	No	No	Surface; soft
Putnam, Conn.	1885	Iron	30	45	No	No	Surface; soft; filt
Rahway, N. J.	1906	Steel	25	125	No	No	Surface; soft; filtered and chlorin
Reading, Mass.	1890	Iron	30	100	No	Yes	Ground; hard; filtered;
Rockville, Conn.	1899	Steel	30	60	No	No	Ground; soft
Rutland, Mass.	1896	Iron	20	90	No	No	Surface; soft
St. Louis, Mo.	1868–70	Iron	5	160	Yes	Yes	Surface
	1886	Iron	6	160	Yes	Yes	Surface; filtered; lime; s cl.
	1898	Steel	6	140	Yes	Yes	do.
	1908	Steel	30	34.8	No	Yes	do.
Seattle, Wash. (3 standpipes; 2 enclosed)	.....	.....	.....	.....	.....	.....	.....
Seneca Falls, N. Y.	1896	Iron and Steel	30	100	No	No	Surface; hard; filtere
Sewickley, Pa.	1901	Steel	20	110	No	No	Surface; hard; f

MARY OF REPORTS ON PAINTING THE INTERIOR SURFACE OF STANDPIPE. Part 2.

er of Water.	Date When Painted. (Interior.)	Preparation of Surface.	No. of Coats.	Kind of Paint.	Amount and Cost, Including Applying.	Condition of Standpipe.
ce; soft	.....	Scraped and wire brushed each time	.....	Various asphalt variations and hot Alcatraz asphalt §	.....	18 times between 1878 and 1906; 1 to 2-year intervals. Used Prince's Mineral Brown. Taken down in 1909.
.....	1908	.....	2	Met. P. & W. Co. graph. elast. No. 1	50 gal.	About all gone in 8 years.
	1916	.....	1	Bit. mixture put on boiling hot over layers of asphalt varnish	14 bbl.	.....
ce; soft	1888 new	.....	.....	.....	.....	.....
	?	Light brushing	1	Graphite	.....	.....
	?	Light brushing	1	Asphalt	.....	.....
	1914	Scraped and wire brushed	1	Asphalt	$375	.....
.....	.....	.....	.....	.....	.....	Not painted inside since original construction.
ce; soft	1897	.....	2	Asphalt	30 gal., $90	.....
	1903	.....	?	Graphite	53 gal., $102	.....
	1909	Wire brushed	.....	Graphite	10 gal., $73	.....
	1912	Wire brushed	.....	.....	$99	.....
d; hard	1911	.....	3	Red lead	.....	Painted when erected.
d; hard	1911	Scraped and wire brushed	1	Red lead	.....	.....
			1	Graphite	.....	.....
d; soft	.....	.....	2	Det. Gr. No. 501 "Hyd. priming" and No. 106 "Hyd. priming"	30 gal. each	Every 3 years. About 7 years ago inside was sand blasted ($1,250), having been neglected some years previously. Some bad pitting; cost labor applying 2 coats, inside and out, $200.
sian	.....	.....	.....	.....	.....	Never painted. "Paint not needed."
.....	1890	.....	3	Asphalt	.....	.....
	1894	.....	2	Asphalt	.....	Paint mostly gone.
	1900	.....	2	D.M.C. on one half;	.....	Paint mostly gone.
			2	Kauri zinc paint on remainder		
	1907	.....	2	Chrysolite	31 gal.	D.M.C. all gone on 5 lowest rings; zinc paint on some; gone on others.
	1911	.....	2	Creolastic black	.....	.....
red; alum	1912	Scraped and wire brushed	.....	Graphite	.....	.....
	1916	Scraped and wire brushed	2	S. & W. metallistic	45 gal., $382*	.....
e; soft	1894	.....	2	Iron metallic paint	10–12 gal.	Not durable.
	1913	Scraped and wire brushed	2	Graphite ("metallistic")	$200	.....
soft; cl.	1907	Scraped and wire brushed	1	Asphalt	About 20 gal.	Corrosion very slight; water leaves deposit which seems to protect metal.
.....	1881	.....	.....	.....	.....	.....
	1896	.....	2	P. & B. No. 2	30 gal.	Inside badly pitted.
	1898	.....	2	D.M.C.	30 gal.	Badly scaled.
	1902	.....	2	D.M.C.	33 gal.	Paint entirely gone.
	1911	.....	2	Creolastic	.....	.....
.....	1891	.....	3	Asphalt	.....	.....
	1905	.....	2	Chrysolite	35 gal.	.....
soft	1900	Scraped	2	Graphite	1 bbl.	.....
	1905	.....	2	Graphite	.....	.....
	1909	.....	2	Graphite	.....	.....
	1912	.....	2	Graphite	.....	Should have been painted this year (1916).
filt.; cl.	1900	.....	1	Red lead	.....	.....
			2	Dixon's graphite	.....	.....
lt.; cl.	1882	.....	3	Lead paint	.....	.....
lt.; cl.	1900	.....	3	Lead paint	.....	.....
; hard	.....	.....	.....	.....	.....	Never painted since built. Expect to paint 1917.
.....	.....	.....	.....	.....	.....	All painted 1906, and expect to paint 1917.
; soft	1909	.....	2	Ferrubron	.....	.....
	1914	.....	.....	.....	.....	Outside only.
; soft	1900	.....	.....	Red lead	.....	.....
	1906	Scraped and wire brushed	2	Ferrubron	.....	.....
	1912	.....	.....	.....	.....	Outside only.
; soft	1912	.....	.....	Ferrubron	.....	.....
t; filtered	1885	.....	3	Asphalt	.....	.....
	1893	.....	1	Asphalt	.....	.....
	1896	.....	1	Asphalt	.....	.....
	1905	Dried and scraped	2	Chrysolite	25 gal.	2 bottom sheets and part of third rusty, top sheets in poor shape.
tered and alum lorine	1906	.....	2	Dixon's sil. graphite	.....	Upper 30 feet.
	1913	.....	1	Red lead	.....	.....
			1	Dixon's graphite	.....	.....
red; lime; alum	1895	Wire brushed	1	Government waterproof	$376*	.....
	1897	Wire brushed	1	Smith's D.M.C. coating	$450*	.....
	1901	Wire brushed	1	Smith's D.M.C. coating	$517*	.....
	1904	Wire brushed	1	Smith's D.M.C. coating	$616*	.....
	1909	Wire brushed	1	Smith's D.M.C. coating	$718*	.....
	1913	Wire brushed	2	Bitumastic enamel	$1 609*	.....
soft	1914	Wire brushed	1	Asphalt	$125*	.....
soft	1896	.....	.....	Red mineral paint	.....	Not painted since.
ce	.....	.....	.....	.....	.....	Not painted during its life. Abandoned 19(?) Badly pitted at waterline only.
e; sulph. ir., al.,	.....	.....	.....	.....	.....	Interior not painted; still in service; "corrosion negligible."
	1898	.....	2	Red lead	.....	.....
	1915	Scraped and wire brushed	2	Red lead	400 lb. lead.; 15 gal. oil, 5 gal. turp.	Badly corroded in spots. Generally protected by lime coating.
	1908	.....	2	Graphite	.....	.....
	1915	.....	.....	Red lead	.....	No paint left; very little corrosion; lime coating.
.....	.....	.....	1	Asphalt on inside	About 25c. per square yard	Paint about every 2 years.
tered; alum	1901	Scraped and wire brushed	2	.....	.....	Probably painted in 1917.
	1907					
	1911					

Portland, Ore.	[illegible]09	Steel	16	40	No	No	Surface; soft
	†1890	Iron?	25	100	No	No	Surface; soft
	1912	Steel	18	61	No	No	Surface; soft
Putnam, Conn.	1885	Iron	30	45	No	No	Surface; soft; filtered
Rahway, N. J.	1906	Steel	25	125	No	No	Surface; soft; filtered and alum and chlorine
Reading, Mass.	1890	Iron	30	100	No	Yes	Ground; hard; filtered; lime; alum
Rockville, Conn.	1899	Steel	30	60	No	No	Ground; soft
Rutland, Mass.	1896	Iron	20	90	No	No	Surface; soft
St. Louis, Mo.	1868–70	Iron	5	160	Yes	Yes	Surface
	1886	Iron	6	160	Yes	Yes	Surface; filtered; lime; sulph. ir., al., cl.
	1898	Steel	6	140	Yes	Yes	do.
	1908	Steel	30	34.8	No	Yes	do.
Seattle, Wash. (3 standpipes; 2 enclosed)	.....	.....	.....	.....	.....	.....	.....
Seneca Falls, N. Y.	1896	Iron and Steel	30	100	No	No	Surface; hard; filtered; alum
Sewickley, Pa.	1901	Steel	20	110	No	No	Surface; hard; hypo.
Sharpsville, Pa.	1900	Steel?	20	40	No	No	Hard
Spencer, Mass.	1899	Steel	40	39	No	No	Surface; soft
Spokane, Wash.	1904	Steel	30	70	No	No	Ground; hard
	1908	Steel	30	70	No	No	Ground; hard
Summit, N. J.	1907	Steel	12	75	No	No	Ground: hard
	1890	Iron	25	65	No	No	Ground; hard
Syracuse, N. Y.	1909	Steel	66	51.3	Yes	Yes	Surface; hard
Tacoma, Wash.	1890	Iron	20	125	No	No	Surface; hard; cl.
	1909	Steel	40	65	.....	.....	.....
	1910	Steel	30	70	.....	.....	.....
Tisbury, Mass.	1886	Iron	20	50	No	No	Ground; soft
Toledo, Ohio	1873	Iron	5	224	Yes	.....	Hard; filtered; sulph. iron; lime; hypo.
Tuckahoe, N. Y. (New Rochelle)	1894	.....	60	60	No	No	Surface; cl.
Ventnor City	Abt. 1907	Iron?	20	100	No	No	Ground; hard
Vincennes, Ind.	1886	.....	22	200	No	No	River; filtered; alum
Washington, D. C.	1904	Steel	19	40	Yes	Yes	River; med.; filtered; alum
Waterloo, N. Y.	1914	Steel	20	40	No	Yes	.....
West Orange, N. J.	1902	Steel	35	35	No	Yes	Surface; soft; filtered; alum; cl.
Westport, Conn.	1892	Iron	25	65	No	No	Ground; soft
Weymouth, Mass.	1885	Iron	40	75	No	No	Surface; soft
Winchester, Mass.	1894	Steel	40	40	No	No	Surface; soft
Winchester, Ky.	1891	.....	25	75	.....	.....	.....
Windsor, Conn.	1916	Steel	30	105	No	No	Surface; soft
Winthrop, Mass.	1909	Steel	40	100	No	No	Metropolitan
Wolcott, N. Y.	1912	Steel	15	85	No	No	Spring; hard
Woonsocket, R. I., No. 1	1884	Iron	50	30	No	No	Surface; soft
No. 2	1889	Iron	50	35	No	No	.....
No. 3	1891	Iron	76	30	No	No	.....

* Includes outside.

† Not including paint.

1909	.....	2	Ferrubron	.....	Outside only.
1914	.....	.....	.....	.....	.....
1900	.....	.....	Red lead	.....	.....
1906	Scraped and wire brushed	2	Ferrubron	.....	Outside only.
1912	.....	.....	.....	.....	.....
1912	.....	.....	Ferrubron	.....	.....
1885	.....	3	Asphalt	.....	.....
1893	.....	1	Asphalt	.....	.....
1896	.....	1	Asphalt	.....	.....
1905	Dried and scraped	2	Chrysolite	25 gal.	2 bottom sheets and part of third rusty, top sheets in poor shape.
1906	.....	2	Dixon's sil. graphite	.....	Upper 30 feet.
1913	.....	1	Red lead	.....	.....
		1	Dixon's graphite	.....	.....
1895	Wire brushed	1	Government waterproof	$376*	.....
1897	Wire brushed	1	Smith's D.M.C. coating	$450*	.....
1901	Wire brushed	1	Smith's D.M.C. coating	$517*	.....
1904	Wire brushed	1	Smith's D.M.C. coating	$616*	.....
1909	Wire brushed	1	Smith's D.M.C. coating	$718*	.....
1913	Wire brushed	2	Bitumastic enamel	$1 609*	.....
1914	Wire brushed	1	Asphalt	$125*	.....
1896	.....	.....	Red mineral paint	.....	Not painted since.
.....	.....	.....	.....	.....	Not painted during its life. Abandoned 19 (?) Badly pitted at waterline only.
.....	.....	.....	.....	.....	Interior not painted; still in service; "corrosion negligible."
1898	.....	2	Red lead	.....	.....
1915	Scraped and wire brushed	2	Red lead	400 lb. lead.; 15 gal. oil, 5 gal. turp.	Badly corroded in spots. Generally protected by lime coating.
1908	.....	2	Graphite	.....	.....
1915	.....	.....	Red lead	.....	No paint left; very little corrosion; lime coating.
.....	.....	1	Asphalt on inside	About 25c. per square yard	Paint about every 2 years.
1901	Scraped and wire brushed	2	.....	.....	Probably painted in 1917.
1907					
1911					
1907	Brooms and wire brushed	1	Carbon coating	25 gal., $60	.....
1911	.....	1	Carbon coating	30 gal., $100	.....
1900	.....	1	.....	.....	Not painted inside since erection.
1899	.....	1	.....	.....	.....
1904	Wire brushed	1	Nat. P. & V. Co. graph. elast. paint	$68*	.....
1912	Wire brushed	1	Nat. P. & V. Co. graph. elast. paint	$60	.....
1904	Wire brushed	1	Asphalt	.....	.....
1908	.....	1	.....	.....	.....
1907	.....	2	?	.....	.....
1914	Scraped and wire brushed	2	Hot coating similar to bitumastic	.....	.....
1890	.....	2	?	.....	.....
1894	Scraped and brushed	2	White lead	.....	.....
1900	.....	2	Hot Asphalt	.....	.....
1912	.....	2	Dixon's graphite	35 gal.	.....
1910	.....	1	Red lead	.....	Inside now quite badly pitted. Expect to sand blast and paint in 1917.
		2	Carbon coating		
.....	.....	.....	Red lead	.....	.....
.....	.....	.....	Red lead	.....	.....
.....	.....	.....	Red lead	.....	.....
.....	Scraped and wire brushed	2	White lead	15–20 gal., about $50	Every other year for 10 years past.
.....	.....	.....	Probably hot pitch similar to C. I. pipe coating	.....	Not painted since 1873. Now out of service.
1912	Scraped and wire brushed	2	Red lead	.....	.....
1913	.....	2	Red lead	.....	.....
1914	.....	2	Red lead	.....	.....
.....	.....	.....	.....	.....	Painted about 2 years ago; don't know with what; not very satisfactory.
1910	Scraped and wire brushed	2	Graphite	.....	Much ice each winter in standpipe.
1910	Scraped and wire brushed	1	Chrysolite	12 gal., $65	.....
1915	.....	1	Chrysolite	12 gal., $65	.....
1914	.....	1	Dixon's graphite	.....	.....
1908	Scraped and wire brushed	.....	Dixon's graphite	25 gal., $32†	.....
1916	.....	.....	Bitumastic enamel (hot)	.....	.....
1890	Scraped and wire brushed	2	Government waterproof	$42‡	.....
1892	.....	1	Government waterproof	$63‡	.....
1894	.....	2	Government waterproof	$56‡	.....
1896	.....	2	Government waterproof	$44‡	.....
1899	.....	2	Government waterproof	$673‡	.....
1904	.....	2	Waterproof paint	$569‡	.....
1907	.....	2	Waterproof paint	$620‡	.....
1911	.....	2	?	$550‡	.....
1915	Scraped, brushed and chip hammered	2	W. H. & Co. red lead in oil	40 gal., $643	.....
1910	.....	2	Elastic graphite	35 gal.	"Lots of ice."
1916	.....	.....	.....	$30 for painting; $25 scraping and wire brushing	Asphalt failed after 1 year; another paint no better; el. graph. painted, 2 coats, lasted 3 years; another 2 coats, 6 years.
1891	.....	3	Asphaltum	.....	.....
1905	.....	2	Chrysolite	30 gal.	.....
1916	.....	1	Det. graph. Penstock paint	30 gal.	.....
		1	D. G. No. 106	.....	No data.
1909	.....	.....	.....	.....	Poor job.
1914	.....	2	Metropolitan specifications	$475	.....
1913	.....	2	Asphalt	$25	Will be painted next year.
1903	Scraped and wire brushed	2	Durable metal coating	24 gal., $139	.....
1905	Scraped and wire brushed	2	Durable metal coating	24½ gal., $130	.....
1907	Scraped and wire brushed	2	Durable metal coating	24 gal., $130 ±	.....
1909	Scraped and wire brushed	2	Durable metal coating	24 gal., $133	.....
1914	Scraped and wire brushed	2	Durable metal coating	24 gal., $140 ±	.....
1903	Scraped and wire brushed	2	Durable metal coating	27 gal., $162	.....
1905	Scraped and wire brushed	2	Durable metal coating	28½ gal., $152	.....
1907	Scraped and wire brushed	2	Durable metal coating	28 gal., $146 ±	.....
1909	Scraped and wire brushed	2	Durable metal coating	28 gal., $155	.....
1914	Scraped and wire brushed	2	Durable metal coating	28 gal., $167 ±	.....
1902	Scraped and wire brushed	2	Durable metal coating	46 gal., $204	.....
1904	Scraped and wire brushed	2	Durable metal coating	52 gal., $207	.....
1906	Scraped and wire brushed	2	Durable metal coating	52 gal., $196	.....
1908	Scraped and wire brushed	2	Durable metal coating	51½ gal., $242	.....
1910	Scraped and wire brushed	2	Durable metal coating	51½ gal., $217	.....
1914	Scraped and wire brushed	2	Durable metal coating	51 gal., $240 ±	.....

‡ Not including labor. ¶ Reconstructed 1916. § None lasted over two years.

In an attempt to bring together such information as may be obtainable, relative to actual experience with standpipe paints, Messrs. Metcalf & Eddy sent inquiries to water works in the northern and eastern parts of the United States where iron or steel standpipes are in use, requesting information as to the dates of painting, kind of paint used, preparation of the surface for painting, and other significant data. In general, the water works superintendents were generous with their responses, which were received during the winter of 1916–17, but in a disappointingly large number of cases the responses were, in effect, — "The writer has been here but a short time. The former superintendent left no records, and I do not know what paint was used or when it was applied."

The accompanying tabulation contains the significant data received in response to this inquiry, together with some information available from other sources. Unfortunately, it has not been practicable to bring the information down to date before presenting this paper. The returns, however, represent the conditions existing up to the time the United States entered the war, and it is probably fair to assume that very little in the way of standpipe maintenance has been done during the period of the war.

The data tabulated are not susceptible of being summarized or averaged. In a few cases it will be noted that the standpipe has not been painted since erection. There are doubtless cases in which the quality of the water is such that it protects rather than corrodes the metal. Such cases are, however, rare, and the experience tabulated seems to indicate that as a rule an iron or steel standpipe should be thoroughly cleaned and painted inside, at least as often as once in four or five years. Perhaps, however, if the cleaning were as thorough as would be accomplished by means of the sand blast, and if a protective coating were then properly applied, the interval between paintings could be materially extended.

In response to the letter of inquiry, Mr. A. H. Kneen, of Philadelphia, sent a report entitled, "Painting the Inside of Standpipes," which is submitted herewith as an appendix, and which contains the best and most complete comparative data which have come to the writer's attention.

Mr. Kneen painted two standpipes with vertical stripes of different kinds of paint, and observed the conditions after two or three years of service. The only paints which gave reasonably good service were a red oxide of iron paint, and red lead.

Most of the paints used were undoubtedly proprietary articles, and although one red oxide of iron paint showed "good" or "very good" results, several others characterized the same way in his tabulation gave "bad" or "very bad" results. It is to be noted, too, that red lead when used was employed only in the first coat, yet the results were characterized as "good" or "very good." It is not impossible, therefore, that two or three coats of red lead would have shown better protection than any of the other paints.

The engineers of the Metropolitan Water Works have adopted the policy of cleaning the steel by sand blast, and applying three coats of red lead to the interior surface of their steel standpipes. The following quotation from the fifteenth annual report of the Metropolitan Water and Sewerage Board describes the cleaning and painting of the Bellevue Hill standpipe:

"On March 25 the tank was taken out of service and drained, and the work of sand blasting and painting the steel was begun March 30 by the W. L. Waples Company of Boston, subcontractor for this work. The plant used consisted at first of a twenty horse-power gasoline-engine-driven air compressor, a compressed air reservoir, two lines of air hose and two nozzles. Sand blasting was stopped in the latter part of the afternoon of each day, and the cleaned surfaces were painted before rusting commenced. The force employed included 1 foreman, 2 painters, who also did sand blasting, and 1 helper. This force could sand blast and paint an area of about 330 sq. ft. per day. Later, in order to increase the rate of progress, a second compressor, operated by an automobile engine, was installed on April 19. The entire inside and outside surface of the tank, having an area of 35 650 sq. ft., was sand blasted and painted. Work was completed June 14, with the exception of the third coat on the outside, which has been deferred until after the masonry tower which encloses the tank is completed. All painting materials were furnished by the department, but were mixed by the contractor under the direction of the engineer. For the inside of the tank, National Lead Company's red lead in oil paste, litharge, and Spencer-Kellogg & Son's boiled linseed oil, were used; the first coat natural color,

the second and third coats tinted with lampblack in oil. For the outside of the tank, red lead paste, raw linseed oil, and drier were used for the first coat, and for the second coat white lead, raw linseed oil, turpentine, and drier tinted with lampblack were used. One gallon of red lead paint was sufficient to cover 700 sq. ft. of surface with one coat. The subcontractor's price for sand blasting and painting the tank was $1 600. . . ."

The writer inclines to the opinion that the method just quoted represents the best practice of the present time. He would put especial emphasis on the thorough cleaning of the metal, and the *immediate* application of the paint to the cleaned metal before the latter has cooled and moisture has condensed upon it.

The following quotation is pertinent in this connection:

" Every specification for painting bristles with clauses prescribing what shall or shall not be done, and still the fact remains that there are more failures than even indifferent successes, especially on work painted at the shops before shipment. The causes for the irregular and indifferent results are not difficult to ascertain. They are the improper application of the paint to dirty, greasy, moist or chilled, rusty or mill-scaled surfaces. No marked improvement in these uncertain results can be had until the same importance is attached to the ' paint question,' not only on paper, but in the actual supervision of the painting in all of its stages, as is given to the minutest construction details."*

With regard to the coating to be applied to the metal after cleaning, it appears probable that not only red lead, but several of the graphite and red-oxide-of-iron paints, and perhaps certain enamel-like coatings, will give satisfactory protection. From such information as he has, the writer believes red lead to be the best. Wood, in " Rustless Coatings," says, —

" The protective qualities of a well-oxidized pure red lead and a pure oil paint, properly applied to any structure under any exposure, except to the action of hydric-sulphide gas, cannot be gainsaid."

It has been used for many years for painting the bottoms of steel and iron ships, and has given the best satisfaction of any paint used for that purpose. No other substance has been put to such severe trial and shown so good results; but unfortunately the

* " Rustless Coatings," by M. P. Wood. (New York, John Wiley & Sons, 1904.)

use on standpipes has been comparatively limited, — probably because of a lurking, though unfounded, fear of lead poisoning if the water remains in contact with red lead paint.

It is obviously unfortunate that the data available are so fragmentary and inconclusive. It is to be hoped that the superintendents having charge of iron and steel standpipes will realize the necessity for more definite information and will make careful record of all the conditions affecting the durability of standpipe coatings, and that at some future time it may be possible to bring the data together and draw positive conclusions from them.

APPENDIX.

Painting the Inside of Standpipes.*

To obtain better information as to a suitable paint for protecting iron under water, the writer decided to paint the inside of a standpipe with different paints, for experimental purposes.

The first samples were applied in August, 1909, the iron being carefully cleaned with wire brushes, and loose scale chipped to clean iron. The results of our experiments to date may be of interest to water works having standpipes and towers, and the results that we have obtained to date are tabulated herein.

Our experiments have been applied particularly to the inside of the tank, as we have found that the outside can be protected by a good lead, iron oxide or graphite paint, which, if of proper quality and properly applied, will protect the iron for at least five years, unless subject to unusual conditions. Usually the appearance of the outside will call for painting before the necessity.

TABLE 1.

Tank 40 ft. in diameter by 50 ft. in height. Samples about 25 ft. in width by 50 ft. in height.

	Condition. Date of Inspection.	
Kind of Paint. Two Coats. Date applied, August, 1909.	Tank Half Full of Water, April 27, 1911.	Tank Empty, September, 1912.
1. Iron oxide	Good.	Fair.
2. Iron oxide	Bad.	Bad.
3. Graphite — black	Bad.	Bad.
4. Asphaltum — black	Very bad.	Very bad.
5. Portland cement (brushed on)	Very bad.	Very bad.

* By A. H. Kneen, Engineer, 112 No. Broad Street, Philadelphia.

In 1910 a smaller tank than the first one used for experiments was erected, and this was painted on the inside with different paints, and is still being used for experimental purposes as it is more accessible than the first.

The kinds of paint applied to the two tanks, and the results found by inspection, are listed in Tables 1 to 4 — Tables 1 and 2 covering the first tank, and Tables 3 and 4 covering the second tank. The manufacturers of the various paints used have been omitted.

TABLE 2.

Same tank as Table 1. Samples about 8 ft. in width by 50 ft. in height.

Date applied, September, 1912.	Date of Inspection. Tank Half Full, May, 1914.	Tank Empty, May, 1916.
1. Oxide of iron — red	Very good.	Very good (best).
2. Oxide of iron — black	Very bad.	Fair.
3. Tar base — black	Very bad.	Very bad.
4. Oxide of iron — red	Fair.	Bad.
5. Oxide of iron — red	Fair.	Bad.
6. Pitch — black	Very bad.	Very bad.
7. Graphite — carbon	Very bad.	Fair.
8. Graphite — carbon	Very bad.	Fair.
9. Oxide of iron — red	Fair.	Good.
10. Car. coating — black	Good.	Very bad.
11. Oxide of iron — red	Fair.	Fair.
12. Oxide of iron — red	Fair.	Bad.
13. Oxide of iron — red	Very bad.	Bad.
14. Tar — black	Very bad.	Very bad.
15. Red lead, first coat; metallic brown, second coat	Good.	Good.
16. Flexible tank oxide of iron—red	Good.	Good.

Repainted May, 1916, with iron oxide paint, and experiments discontinued.

TABLE 3.

Tank 30 ft. in diameter by 39 ft. in height. Samples about 16 ft. wide and 39 ft. high. Painted May, 1910.

Paint — Two Coats.	Condition: Date of Inspection. Tank Half Full of Water, February, 1911.	Tank Empty, September, 1914.
1. Graphite	Bad.	Bad.
2. Rubber paint	Bad.	Bad.
3. Oxide of iron — red	Good.	Very good.
4. Oxide of iron — red	Bad.	Bad.
5. Red lead (1), metallic brown (2)	Fair.	Good.
6. Oxide of iron — red	Good.	Bad.

TABLE 4.

Same tank as Table 3, repainted on inside, September, 1914. Twelve samples about 8 ft. by 39 ft. in height.

Kind of Paint — Two Coats.	Inspected December 26, 1916. Tank Half Full of Water.
1. Oxide of iron — red	Good.
2. Pitch — black	Bad.
3. Oxide of iron — red	Bad.
4. Asphalt and Portland cement	Bad.
5. Red lead, first coat; metallic brown, second coat — brown	Very good.
6. Red lead lute, first coat; metallic, second coat, brown	Bad.
7. Oxide of iron — red	Bad.
8. Tank paint, pitch — black	Bad.
9. Tank paint, oxide of iron — red	Bad.
10. Roof coating — pitch — black	Bad.
11. Tank paint — oxide of iron — red	Good.
12. Sticktite No. 3, pitch (black)	Bad.

Samples marked "Good" and "Very good" had comparatively few tubercles on surface and no scaling or blistering. Samples marked "Fair" had more tubercles and some scaling and blistering. In samples marked "Bad," the surface was fairly well covered with tubercles and some blistering and separations had taken place. In samples marked "Very bad," the surface was generally covered with tubercles and the paint badly scaled and very badly blistered. In the painting of September, 1914, the red lead and metallic brown paint used was mixed on the ground by our chief painter and the best quality of everything was used.

Cost.

Labor cost, which covers cleaning and the application of two coats of paint, is usually less than $20.00 per thousand square feet. The amount of paint required for two coats on the inside has averaged 5½ gal. per thousand square feet, or one gallon of paint covers about 180 sq. ft. of iron with two coats. Assuming that the paint costs $1.50 per gallon, the cost of paint for two coats would be $8.25 per thousand sq. ft., which, added to the labor cost, makes the total cost $28.25 per thousand square feet.

The iron can be prepared for the paint by the sand blast, and other protective coatings can be secured with five-year guarantees, but the expense of such cleaning and such application at the prices quoted is, in our judgment, too great to warrant the expenditure.

Under the writer's supervision, we have had the inside of fifteen standpipes painted and repainted in the past seven years, the combined area of which is over 112 000 sq. ft., and the results obtained are similar to those

obtained in the experimental tanks. Our conclusion to date is that paints having pitch or asphalt for a base, applied in this manner, are not suitable for iron in contact with water, but that two-coat work with a good quality of iron oxide paint or a paint with a good red lead base for the first coat, and an iron oxide paint for the second coat, if the iron is properly cleaned and the paint is properly applied, will protect the iron in contact with water for at least four years, unless the water is of unusual quality or the conditions are different than usually met with in water-works practice.

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DISCUSSION.

MR. FRANK L. FULLER. I do not remember that Mr. Sherman gave us anything in regard to the cost of this sand blasting operation.

MR. SHERMAN. The cost of the whole operation is given in the Metropolitan Report, but I can't give you the cost of the individual items because I haven't the information for it.

I will say, Mr. President, that wherever data are given for the cost of painting, it is for painting the interior surface. Perhaps I did not make it as clear as I should at the beginning that I confined my paper to the painting of the interior. The exterior I am not particularly interested in. Any house painter can paint the outside of a standpipe, and, anyway, you will know if it does

not last. But painting the inside is another matter. In many cases the figures given cover the inside and outside, but I think I have made that clear in my table. Unfortunately, it was not always possible to tell what the cost of painting the inside was. As to how thorough the cleaning was, you will have to draw your own inference. Nobody but the man who did it probably knows how thorough the cleaning was.

MR. RUDOLPH HERING. Mr. President, I should like to say a few words in reference to this subject, although it is not directly the subject of the paper, but it is one which I have always thought should be considered.

Many years ago I was in the Rocky Mountains, and we noticed that our hair stood on end, and very soon we found out that electricity was passing up through the mountain and escaping, and we were right in the current.

Now, we know that that happens. We know that, for instance, a lonesome tree on a plateau is easily struck by lightning, and if you examine that tree you will find a current of electricity going up most any time. I stood on one of these standpipes at one time to see whether there was an electric current going up there. I took off my hat, as did also my friend, and sure enough our hair stood up on end. That shows that an electric current passes up a great many of these standpipes.

We know from our water pipes in the ground how much we have suffered from electric currents passing through those water pipes. They have been corroded. And it struck me, although it is out of my line, that in the construction of standpipes this question of electricity should be considered, and I was waiting for some remarks on that in Mr. Sherman's paper, so I thought I would relate this old story.

It seems to me that if we could, in addition to the paint, which of course is necessary, find some way by covering the top, and also the bottom, with some insulating material, we could prevent an electric current very frequently, if not always, from passing through that standpipe, and we might increase its life. I merely throw that out as a suggestion.

MR. FRANCIS T. KEMBLE. Mr. Chairman, my experience backs up the previous speaker's experience as to painting the outside of the tanks.

I might say that we have two tanks at New Rochelle, and I have tried employing the same men that we have had painting the inside — real steel workers — on the outside, and at other times I have tried house painters and got just as good results at about one third the cost. On the inside we use red lead paint. The first time I tried cleaning this pipe was about twelve years ago, and there were some pretty bad pittings. At that time we pumped until about midnight and then shut down, and then the next morning the tank would always be drawn down to about the same point, and just above that point was considerable pitting, pretty deep. All that was cleaned out with wire brushes and painted with red lead. About three years afterwards, when again painted, we found nearly all those pittings were in good shape. That red lead took right hold. But a few of them had to be cleaned. We tried doing that every four years, but can't get the labor nowadays.

MR. FRANK A. BARBOUR. I note by this table that the standpipe at Reading, Mass., was covered with one coat of "Government waterproof" some years ago. I should like to have Mr. Bancroft tell us what its condition is at the present time.

MR. LEWIS M. BANCROFT. Mr. President, I can't say anything about the present condition of that standpipe, because we have not opened it. I have not seen the inside of the standpipe since that coating was put on.

MR. A. P. FOLWELL. I notice one of the standpipes here was built over thirty years ago and has never been painted. I was wondering whether Mr. Sherman could tell us anything about that, and what condition the standpipe is in if it has stood thirty years without any paint on it.

MR. SHERMAN. Which one is that? I know there are several there that have been reported as not having been painted.

MR. FOLWELL. That is Norwood, Ohio.

MR. SHERMAN. I do not know anything about that.

MR. FOLWELL. It was built in 1884 and has not been painted, — "Paint not needed."

MR. SHERMAN. There are two or three cases where they have reported "Paint not needed." I do not know whether they know what they are talking about or not.

MR. J. M. DIVEN. That thirty-year old standpipe was probably wrought iron and not steel.

MR. FOLWELL. It was iron.

MR. KEMBLE. There is one little experience we had in connection with our standpipe which may be of interest. This is a tank 60 by 60. It has a 6-in. blow-off on it, and it has a box on the outside. The box had got in bad shape. The box got full of water and it froze and cracked and threatened to let go. We had had some experience before with the tank overflowing and slacking a lot of lime down below which we had to pay for.

The way we met the situation in this case is that we put a trap in that 6-in. pipe and fed a lot of copper wire, and the fellows fished for it up at the top with an iron hook on the end of a line, probably about twenty minutes, patiently trying, and they managed to catch it. They pulled that up and fastened the wire, which is about as heavy as we could get through well, to a plug that had a bore right through it with an eye in each end, and we attached this wire at the small end of the plug. At the other end we had two eyes, and managed to bring that thing right down in the pipe. Then we plugged it nearly tight, and cut the pipe, put on a new gate, and then took a sapling and used a tackle upon the gate and jammed the plug right out of place and got through without any trouble.

MR. JOHN CULLEN. There are four tanks in Woonsocket; one is concrete, the other three are steel or iron. The first one was a wrought-iron tank. It has been there thirty-five years, or a little more. The tank is in good condition, or was the last time examined, which was five years ago. I don't know about it since. It has not been painted because we cannot get along without it. We can't supply enough water to have it drained off. The other two tanks, which are steel, I expect are much more efficient than the first one is.

MR. H. T. GIDLEY. We have had our standpipe at Fairhaven painted inside — wire-brushed inside and then painted with a hot coating of rubber-elastic nature, and it has been painted five years on the inside, and was examined lately and seems in as good condition, practically, as when it was painted. The outside was painted with lead and oil, and although in fair condition it

rather needed painting again, so that we painted it on the outside this fall with the same preparation that we painted the inside with, only it was a little thinner. We put on two coats.

I understand that Portland had two tanks painted by the same man that painted ours this fall. If there is anybody here from Portland I should like to hear from them about it.

PRESIDENT KILLAM. Mr. Sherman, can you give us any information about cleaning standpipes with gasoline?

MR. SHERMAN. Not a thing, Mr. President. I have heard it mentioned, but I don't know anything about it.

PRESIDENT KILLAM. I think we have all heard more or less about cleaning tanks with gasoline. Is there anybody here who has had experience in that?

MR. KEMBLE. Answering the gentleman from Woonsocket, speaking of not being able to spare his tank, I might say that each time we inspect our tank and empty it we pump right into the mains through a relief valve that connects with one of the reservoirs. You can throw your tank out of service entirely. We have tried that about four times without any trouble.

MR. FRANK L. FULLER. Mr. President, it seems to me that these standpipes are one of the most generally neglected parts of the water-works system. I remember seeing a tank — I forget just where it was, Randolph or Holbrook, or down that way somewhere — that was in a horrible condition. I think it had not been used for a while, but it looked hardly safe to put water into. The rivets were badly corroded, and the plates also somewhat on the inside. And I think there was a ladder on the side, which was all gone except at the bottom of the tank. It seemed to me that some effort ought to be made every three or four years to see that the tank is in good condition, for it is, of course, a very essential part of the system. If the tank becomes disabled so that you can't pump into it, you are in pretty bad shape.

I did not notice whether Mr. Sherman said anything about ladders on the inside of the tank. It has always seemed to me that they were a pretty poor thing to have, that it was a great deal better to have one ladder on the outside and let the inside ladder go. In the old days it used to be very common to have riser pipes and ladders on the inside, which the ice was apt to

get attached to, and as it rose and fell cause damage by tearing them away from the shell, producing leaks. I think those have been to a large extent given up.

PRESIDENT KILLAM. In the Metropolitan District in Boston we have spent considerable time on experimental work in connection with the standpipes. The best paint that we have been able to find was the Dutch Boy red lead. The Dutch Boy red lead people will tell you that litharge should not be added to their paint. But we do not agree with them. We add litharge to harden the paint when we apply it.

We have tried painting standpipes by contractors, the contractors furnishing the paint under specifications, but the most satisfactory way has been to furnish the materials ourselves and let the contractors do the work. It may require a little more material for the contractor to put it on this way, but it pays in the long run.

The cleaning of the old standpipes in every case has been by wire brushes, and the pits thoroughly cleaned, and then the first coat of red lead mixed with the best linseed oil — which at present is hard to find, but we get the best on the market. It costs about three quarters of the labor for cleaning and one quarter for painting the interior of the standpipe, according to our experience.

For the second coat we have put on the Dutch Boy red lead with a little lampblack. Now, that is simply to tone down the red lead so that we can watch the contractor. In that way we know where he has painted and where he has not. For the third coat we put considerable lampblack in, and that is to watch the contractor and also to satisfy the general public. We have found that the general public is a little suspicious of red lead paint, whereas if you tone it down so that it makes a maroon, or something along that line, they do not think so much about it. In fact, at the present time we are mixing our green paint for our steel work from Dutch Boy red lead, using Prussian blue, and so forth.

Another factor which has entered into the painting of standpipes in the Metropolitan District is the ice. While all our tanks are covered, we have more or less ice, especially during a winter the same as two years ago, and the action of ice on the side of the tank not only keeps the tubercles from forming but it

also has a tendency to take the paint off. That was the trouble with the Gilsonite paint which we put on over the red lead in the standpipe at Arlington. The action of the ice on the Gilsonite paint took it entirely off the side of the standpipe, and we found it in the bottom.

In connection with the red lead, three coats of straight red lead, toned down with lampblack or something of that kind, we find wear at least twice as long as red lead covered with some other kind of paint.

On the outside of the standpipe it does not matter so much, although we use the red lead first and then some other paint over that. That is something we can get at at any time.

The tubercles which form on the inside of standpipes seem to be all below the low water line — at least, those of any size. The pits are the deepest at 10 or 15 ft. from the bottom. There has been very little rust formed on the sides, and some on the bottom of the standpipes, but that is easily cleaned.

Mr. E. M. Nichols. I understand in the preservation of metal surfaces the first thing that is necessary is to remove any oxide that may have formed before you apply the coating. The next thing is to apply a coating which will not oxidize, — at least, not very easily.

In mixing red lead or oxide of iron with something else, either boiled or raw linseed oil, it was always my impression that the oil was the biggest part of the whole proposition, while the oxide or lead probably was added to it to give it a little more value; that the oil gave the red lead enough elasticity so that it would not crack, — both of them were a fair preventive against oxidation.

Now, why should red lead be the super article? It is simply because it is a substance of the iron itself. We all know unless you apply the thing properly it does not work. If you have a rusty piece of iron, it will rust through sooner or later.

The whole thing lies in doing it in a proper manner. One of the greatest troubles we have in keeping up our reputation as contractors is the slackness of the men.

Mr. J. F. Sullivan. Mr. President, I should like to get some information from Mr. Sherman. I should like to ask if he has had any experience in using the gun in painting standpipes. At the

present time in Chicopee we have probably one of the largest standpipes in New England, a standpipe 70 ft. in diameter by 130 ft., of iron, holding 1 900 000 gal. of water.

We have three standpipes. The old one is made out of wrought iron, erected twenty-three years, and it has only been painted twice in the twenty-three years. We could not paint it on account of not having sufficient capacity; our supply was too small.

MR. SHERMAN. Do you mean a thin coating of cement applied with the cement gun? Is that the idea?

MR. SULLIVAN. Yes.

MR. SHERMAN. No, I have never seen or known of such a thing. I have known of cement washes being used, — cement applied with a whitewash brush.

MR. T. R. KENDALL. May I ask if Mr. Sherman knows where there has been a gun used for spraying paint. I understand some manufacturer put out a certain kind of nozzle which could be used for spraying paint.

MR. SHERMAN. I do not know whether that has been done or not. The returns which we have received do not indicate the method of applying the paint.

MR. FRANK J. GIFFORD. In answer to the previous speaker I would say that in 1908 the Fall River standpipes were sand-blasted and the paint put on with compressed air, and it seemed to be as satisfactory as with brushes, — perhaps more so. The result was the same; the next year the paint was all at the bottom of the pipe anyway. And that was true with the brushes.

In 1912 they erected a new pipe of steel and that paint was put on with compressed air, but I have never seen the steel tank opened since that time. I left there in 1915. But I think since that time the work has all been done by hand; why, I do not know.

PRESIDENT KILLAM. In regard to the cement wash, I might say that we experimented with that and found it was satisfactory except for the ice. The movement of the ice took off all the cement wash we put on.

SOME DETAILS OF WATER-WASTE PREVENTION SURVEYS.

BY PAUL LANHAM.*

Systems of water-waste prevention surveys as applied in the various cities and by the private companies engaged in that class of work are basically the same. That is, the old Deacon System, of English origin, with its division of the distributing mains into districts and the more or less complete analysis of the total flow, forms the foundation upon which have been constructed the somewhat elaborate and thorough detailed systems of the present day. Two branches of work naturally form the complete system. First must be determined the necessity for the surveys as indicated by the total consumption and per-capita data for the whole plant. This must be divided and separate determination made as to which sections or districts of the city are in condition demanding attention. After this, of course, follow the detailed surveys within these sections by which the actual location and causes of the abnormal or wasteful conditions are determined.

The first and probably most important step in starting a water survey of a city-distribution system is the proper division of the mains into permanent districts. This necessitates a thorough study of the general layout and some knowledge of the direction and rates of flow in the different trunk mains. These latter facts may be easily determined by using portable Pitot tube apparatus at various points. In selecting boundaries for the various permanent districts it must be borne in mind that measurable velocities are necessary at the proposed district measuring points, that valve closures must be made at neutral or nearly neutral flow points to avoid serious interference with pressure and supply, that subsequent work makes the segregation of like consumers in the same district not only desirable but almost necessary, that ample capacity must be provided in mains feeding the district when

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other mains are closed off during the measuring periods, and that the districts must be of such size as to permit a complete detailed survey within a period of one or two months to avoid confusion of data due to changes of season while the work is in progress.

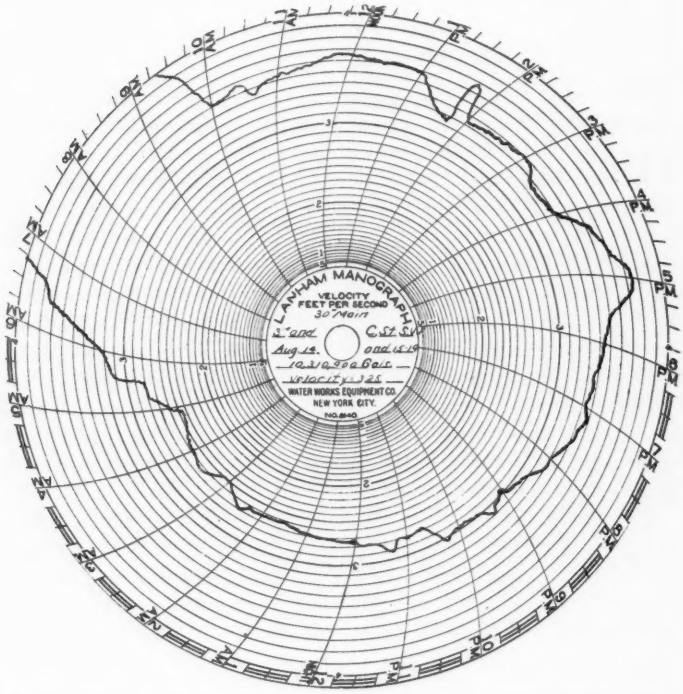


FIG. 1. TYPICAL FLOW CHART TAKEN ON 30-IN. MAIN SUPPLYING PERMANENT WATER SURVEY DISTRICT.

Note high night rate of flow into residential territory.

These points cannot of course be literally carried out in all cases. High- and low-service areas interfere; some sections have natural boundaries which must be followed, regardless of the dictates of the system; and intermixtures of factories with residences in

many cases produce undesirable conditions. Permanent boundaries, however, must be established as near as possible in conformation with the plan, and must thereafter be maintained per-

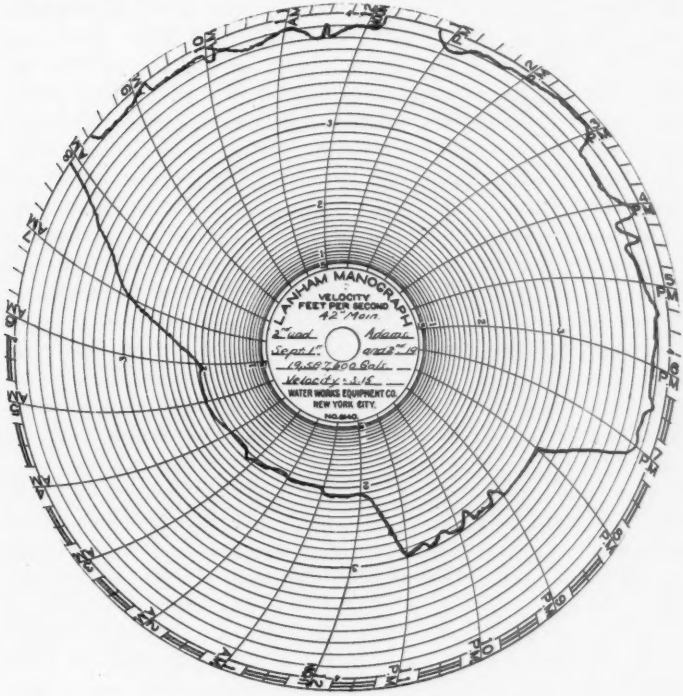


FIG. 2. TYPICAL FLOW CHART TAKEN ON 42-IN. MAIN SUPPLYING LARGE WATER SERVICE AREA.

Note peak loads occurring at 8.00 A.M. and during noon hour. Peak load at noon is an unusual occurrence. Note also rapid decline in rate of consumption after 7.00 P.M. and again at 11.00 P.M.

manently to avoid rendering useless for comparative purposes data previously secured.

Measurement of district flow should be made at as frequent intervals as possible. It would be ideal to maintain permanent recording instruments at the measuring points and keep constant

record of the flow condition. This is impractical because of the extra fire hazard and other risks involved in maintaining a great number of closed valves throughout the system. From four to six measurements of at least seven days' duration should be made if possible of the flow into each district each year. Portable recording Pitot apparatus, which *must* be used upon the detailed flow analysis within each district, is ideally adapted to these measurements, and its use for both purposes simplifies the equipment considerably. These measurements give mean daily consumption, — maximum, minimum, and night rates of flow. Population count made by the inspectors while making the detailed surveys within the districts permit the district per-capita rates to be determined. The per-capita rate and the ratio of the night rate to the mean daily rate of flow are excellent indices of the condition of the district. Of course consideration must be given to the character of the consumption when reaching conclusions based upon these figures. To facilitate this, a census of buildings is also taken during the progress of the detailed surveys, and these data, together with all other, must be recorded permanently for future reference.

Most interesting facts are frequently brought out by study of the flow charts taken upon the various districts, and their value is limited only by the intelligence of the investigator. Cases on record show districts where the night rate of flow exceeds the rate during the daytime; others show a ratio of night rate to mean daily rate, varying from zero to 100 per cent. Charts frequently show abnormally abrupt changes in the flow rate, excessive peak load, indicating over-taxation of certain mains, and many other facts which have their definite causes and reveal, upon study, all the secrets of the distribution system. Extreme variation in conditions will occur, due to variation in usage in industrial plants, season changes, and other causes, so that the data obtained must if possible be compared with previous data obtained under like conditions to determine their full import. A comparison of conditions immediately before and after a detailed survey is particularly interesting and valuable, and the dates of measurements may advantageously be selected to permit this.

In a number of cities different water-service areas, supplied

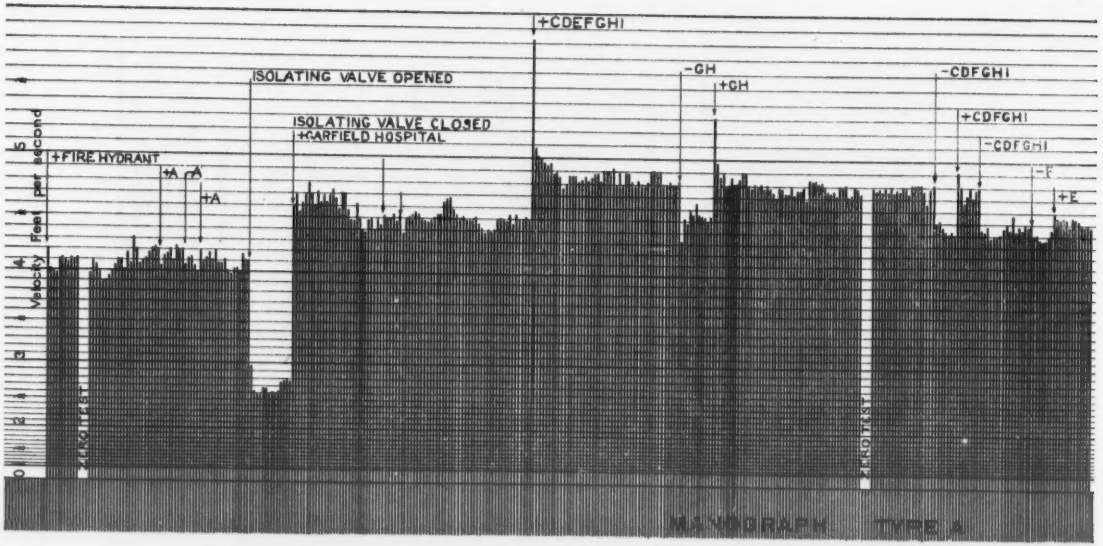


FIG. 3. CHART OF NIGHT SUBDIVISION TEST.

Note fluctuation occurring throughout the test in spite of the fact that the chart was taken on a main supplying residential section after midnight. Repetition of tests and careful computation is necessary to detect differences in rate due to small flows. Chart illustrates method of testing rate of flow into important institution (Garfield Hospital) without interrupting supply.

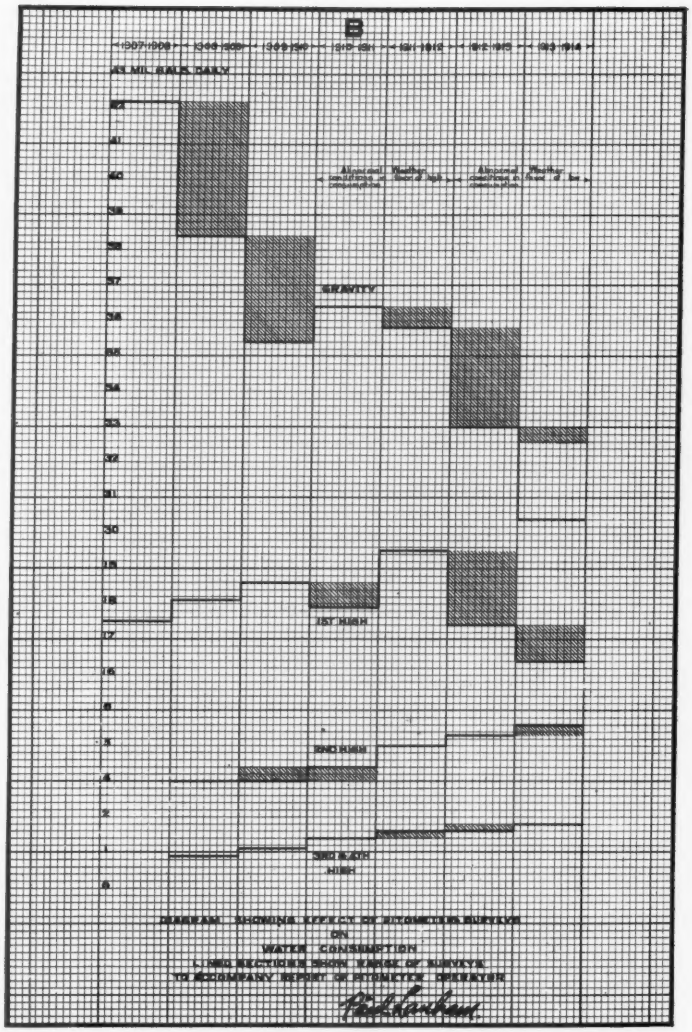


FIG. 4. ILLUSTRATION OF EFFECT OF WATER SURVEYS ON WATER CONSUMPTION.

Note invariable decrease coinciding with surveys as compared to increases at other times. Water consumption in these sections was increasing substantially each year previous to 1906, at which time the water surveys were started.

directly by individual pumps or by trunk lines where Venturi meters have been installed, constitute natural permanent districts which can be observed at all times, either by inspection of the pumping records or the Venturi charts. In many cases these natural districts are too large to be properly treated as permanent survey districts, but they form convenient units for checking total figures obtained by consolidating the data secured upon the permanent districts within their limits. Such data as mean daily consumption, per-capita consumption, and night rate of flow for the entire city should be plotted constantly as a matter of general interest and value. These figures are usually obtainable from pumping station or filtration plant reports. They form the measure of the effectiveness of the surveys and are indisputable.

Detailed surveys within the permanent districts, made for the purpose of *actually* locating and weeding out the wastes and leaks from the legitimate consumption, follow a well-defined basic system also, but the degree of thoroughness and success depends greatly upon the limitations of the pipe system in the matter of valves and stopcocks, and the ability of the operators. Measuring points having been established throughout the permanent district under survey, the portable recording Pitot apparatus is moved from place to place as the work progresses, and each section of main is given close examination. Small temporary test districts are isolated after eleven o'clock at night and the total rate of flow into them observed and recorded on the Pitot chart. Work of testing and inspecting is continued through the night until about four o'clock A.M., when it is found that the rate of flow becomes unsteady and interferes with the tests. Tests are made at this time because legitimate consumption is then at a minimum, while leaks and wastes will still be running at full head. In residential sections the rate during these hours is practically one hundred per cent. illegitimate.

The method of test consists simply of measuring the rate of flow into a limited number of squares and noting either the increase or decrease in this rate caused by altering the number of squares included in the test districts; by "squares" being meant each section of main in a given street lying between adjacent intersecting streets. In most cities, valves are placed at these points.

Of course the location of valves really determines the extent of the main included in each separate test.

To go into detail, assuming a rate of flow of 100 000 gal. per

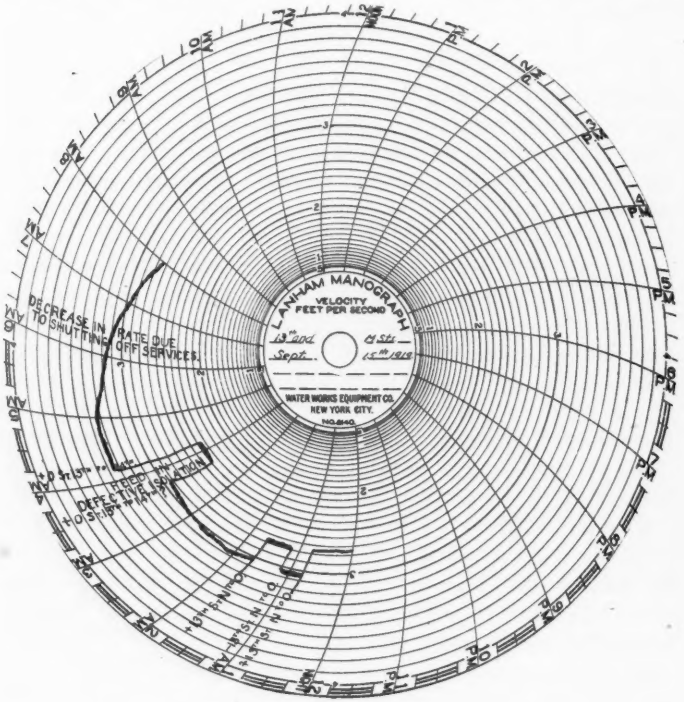


FIG. 5. TYPICAL CHART OF NIGHT SUBDIVISION TEST.

Note abrupt changes in flow rate coincident with valve operation. Note the momentary high rate coinciding with each valve opening, due to drainage from main while shut off preceding the test. In general this indicates a tight shut-off for the square and verifies the existence of a substantial flow.

day, for instance, in a test district of two squares, the rate of flow increasing to 110 000 gal. upon the addition of another square indicates of course that the rate of flow into this additional square is 10 000 gal. daily, or the difference between the rates before and after its addition. Reversing the process, the rate would of

course drop from 110 000 gal. to 100 000 gal., if the square is excluded from the test district. Both methods of testing are utilized, as conditions require. The method of adding squares is preferable, as it keeps the size of the district under test always at a minimum, thereby facilitating the work by frequently excluding for longer periods undesirable fluctuation in certain squares, also by immediately locating this fluctuation upon its appearance upon the chart coincident with the addition of a square under test, permitting the immediate exclusion of this square to avoid its interference with other tests.

The recording apparatus for this testing work should produce a chart visible at all times, have a rapid chart movement, and be quickly responsive to the smallest changes in rate of flow. The use of indicators without the chart is not satisfactory, due to the fluctuating rate of flow always occurring, even in residential sections, in the small hours of the morning. The reasons for these fluctuations constitute somewhat of a mystery, and they interfere seriously with testing where small flows are involved. The locating of the night flow first involves the use of all street valves, and when the flow is definitely determined as to quantity and location within the closest limits permissible with these valves, recourse is had to the aqua-phone or water-phone, and the operators listen with it on each curb stopcock, fire hydrant, lawn-sprinkler connection, or any other fixtures attached to the main within the predetermined limits. Examinations are also made of all sewer manholes, large sewers, electric or other ducts, and advantage is taken of every facility to determine the exact location of the flow. Flows due to fixtures or other causes within the houses or buildings are readily determined when the aqua-phones are placed against the curb stopcocks and the operators hear the flow passing through the pipe. Closure of the stopcock, causing stoppage of the sound, proves that the leak or flow is in the particular service pipe under observation or in the building supplied by it, and the amount is registered by the Pitot recorder, being the reduction in rate of flow coincident with the closure of the stopcock. Flows due to leaks on the mains or on the service pipes between the main and curb stops can be heard on the service pipes or pipe, but these flows will not be affected by closure of the stopcocks, nor will any reduction of rate of flow occur at the

recorder. The total quantity of flow due to these unaccounted for or so-called outside flows may be readily determined by a second test of the entire square with all inside flows shut off at the curb line. It is frequently necessary to drive testholes down to the mains and service pipes to permit the use of the aqua-phone

FIG. 6. SOME DEFECTIVE SERVICE PIPES FOUND BY WATER SURVEYS.

No. 1, corroded iron service; No. 2, defective wiped joint; No. 3, lead pipe damaged by bad workmanship when wiping joint; Nos. 4 and 5, frozen lead pipe; No. 6, corroded thread causing disconnection of iron service; No. 7, electrolysis of iron pipe; No. 8, broken stopcock due to abusive use of curb key.

in definitely locating an underground leak within closer limits than provided by the valves, stopcocks, or other fixtures, increasing loudness of sound at the different points indicating that the operator is nearing the leak. Frequently water or mud will be observed on the end of the steel prod used for this purpose, and this indication is utilized. Proper use of the aqua-phone is really a science, and long experience is necessary for one to become expert in its application to the underground leakage problems.

During the progress of the night tests, the operator in charge makes notes as to each step in the proceedings, and has an instru-

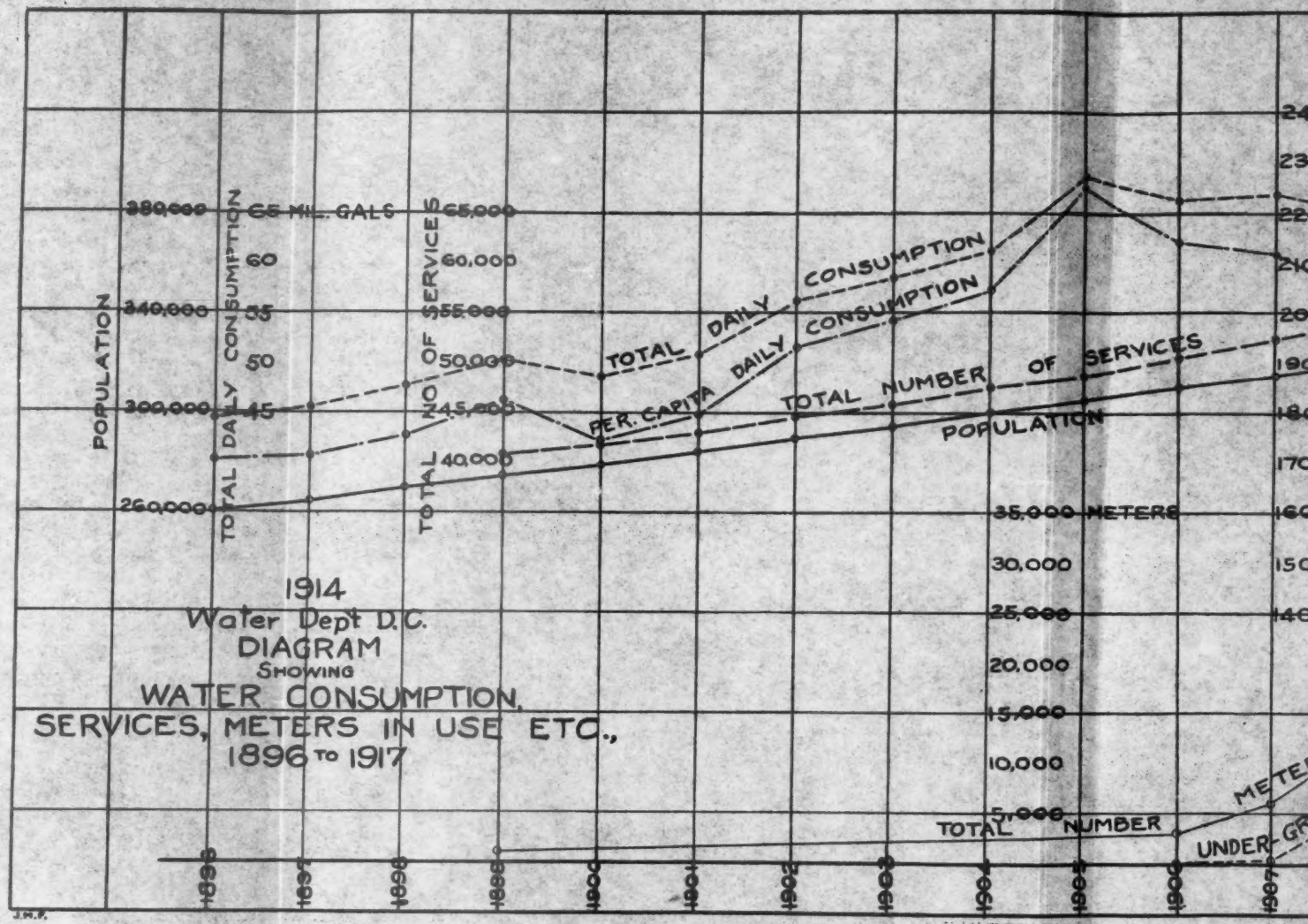
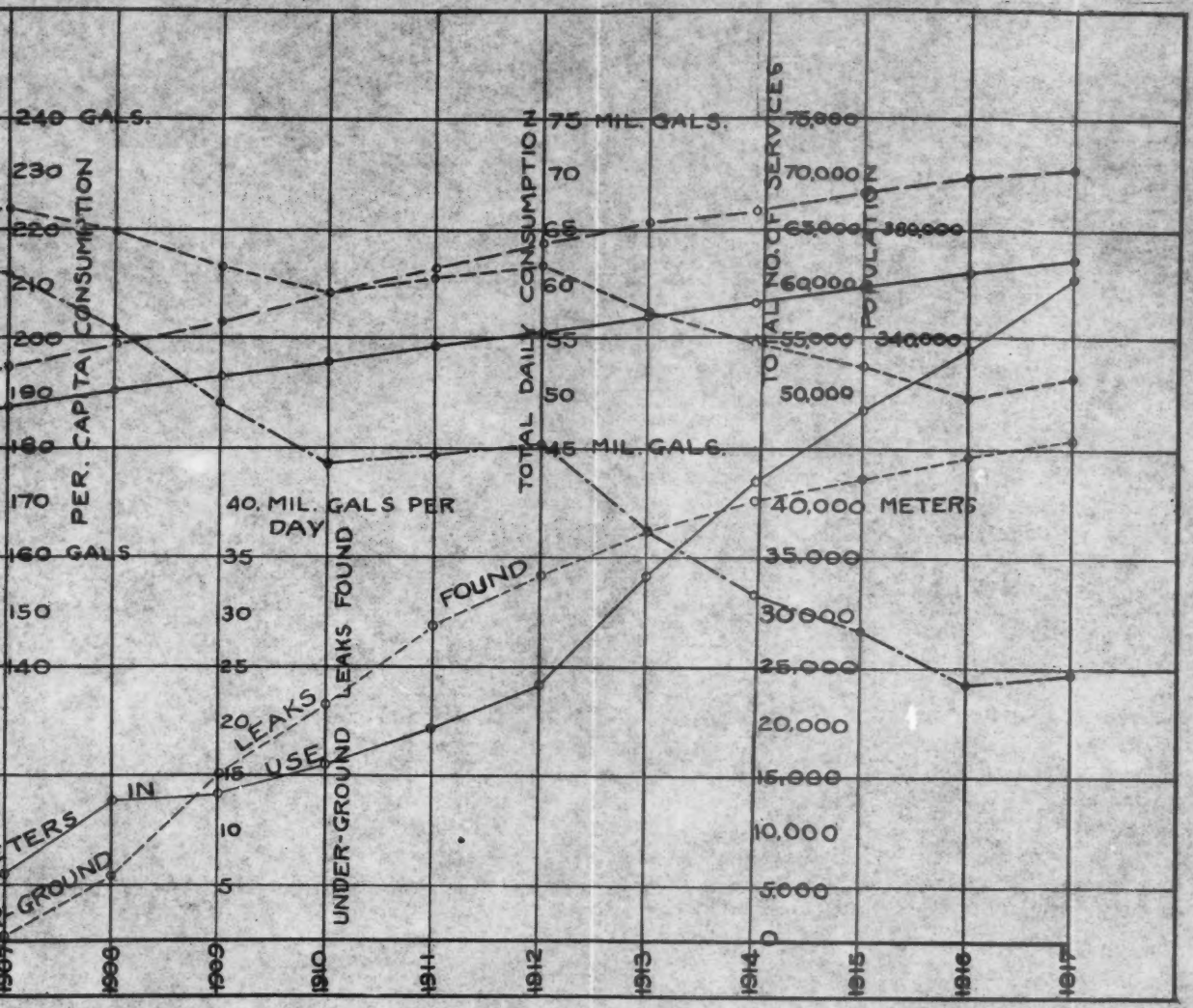


CHART OF TOTAL CONSUMPTION IN WASHING

Showing rapid decline in water consumption due to water surveys and meter installations. Note that co



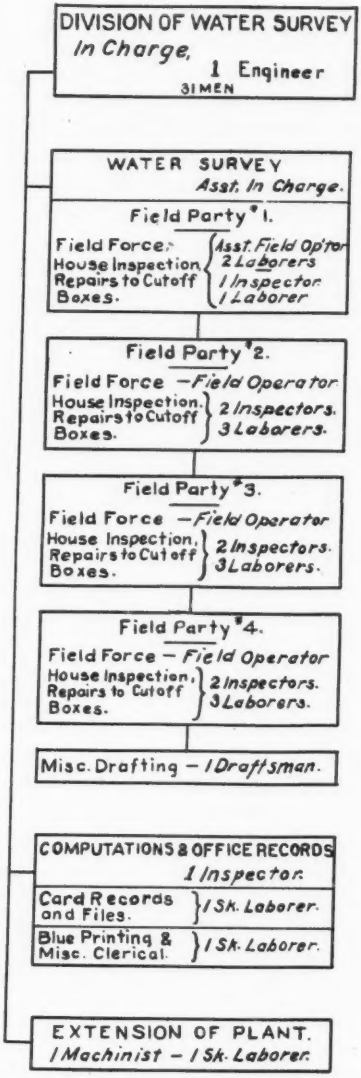
HINGTON, D. C.

at consumption was rising rapidly until 1906, when this work was started.

ment-tender place an identification mark upon the chart at each point corresponding with the test, signals by lanterns or otherwise being utilized, greatly facilitating interpretation of the charts; and this system is superior to the time-schedule system of testing, in which the time of test is noted to be located on the chart later. It is apparent from the description given that the basic system is very simple, and that by the exercise of care and good judgment results should be secured by any one. The difficulties met with in practice are frequently very discouraging, however, and the getting of results in spite of them taxes the ingenuity of the operators. These difficulties consist of inaccurate maps which fail to show important mains, cross connections, valves, and other features vital to the proper isolation of the districts and individual squares, inaccessible curb stopcocks which must be cleaned at the expense of much labor, broken valves and stopcocks, leaking valves, obstructed mains, unrecorded cross-connecting service pipes, and fluctuating rates of flow, causing confusion and wrong deductions.

The organization of a properly balanced force to efficiently handle the water-waste problem is a matter depending considerably upon local conditions. In general, the force should be supervised by an experienced engineer with at least one clerk and one draftsman comprising the overhead organization, and as many field parties as the circumstances demand. Each field party should consist of a chief operator and two or more inspectors, with necessary laboring force to clean out stopcock boxes, open necessary excavations, operate valves, and perform other necessary miscellaneous duties. At least one laborer is required for each inspector, and of course more will be required if many leaks are found.

Waste-prevention surveys have been made in numerous cities along the lines described, and the results have been most gratifying. In one city over 45 000 000 gal. daily underground leakage has been stopped in the past thirteen years. In another, over 2 000 000 gal. daily was the result of only one year's work by a single field party. Reference to official records of Washington, D. C.; Utica, N. Y.; Baltimore, Md.; New York City; Newark, N. J.; Havana, Cuba; Perth Amboy, Kearny, N. J., and many other places, reveals data proving the value of this work beyond all question.



ORGANIZATION CHART.

CARD ENTRIES OF DATA DETERMINED BY WATER SURVEYS OF PERMANENT DISTRICT "E," WASHINGTON, D. C.

(Note improvement of condition on second survey.)

PITOMETER DISTRICT E, SURVEY No. 1.

MEASUREMENT	9/13–19/10		
Mean daily supply			7 638 000 gal. per day
Minimum night rate			6 062 400 gal. per day
Ratio of minimum night rate to mean daily supply			79%
Per capita consumption, taken from resident population			351 gal. per day
SUBDIVISION SURVEY			
Started			
Finished			
Cost			
POPULATION	Metered	Unmetered	Total
Resident	4 281	17 460	21 741
Floating	4 069	9 575	13 644
Total	8 350	27 035	35 385
BUILDINGS			
Dwellings	427	3 826	
Hotels and apartments	51	43	
Restaurants	36	11	
Factories	21	12	
Municipal buildings	7	1	
Federal buildings	0	6	
Miscellaneous	90	422	
Total	632	4 321	
TOTAL NIGHT FLOW DETECTED BY SUBDIVISION TESTS			3 878 000 gal. per day
Due to flow inside metered premises		300 300	gal. per day
Due to flow inside unmetered premises		1 282 000	gal. per day
Due to underground leakage			
Services	1 070 200		gal. per day
Mains	173 200		gal. per day
Unclassified	300		gal. per day
Total		1 243 700	gal. per day
Due to municipal consumption		59 200	gal. per day
Due to federal consumption		411 400	gal. per day
TOTAL FLOW ACCOUNTED FOR			3 296 600 gal. per day
TOTAL FLOW UNACCOUNTED FOR			581 400 gal. per day

PITOMETER DISTRICT E, SURVEY No. 2.

MEASUREMENT 4/19–25/12			
Mean daily supply			6 149 800 gal. per day
Minimum night rate			4 156 800 gal. per day
Ratio of minimum night rate to mean daily supply			68%
Per capita consumption, taken from resident population			282 gal. per day
SUBDIVISION SURVEY			
Started			8/17/11
Finished			4/28/12
Cost			$3 280.26
POPULATION	Metered	Unmetered	Total
Resident	4 783	17 079	21 862
Floating	7 689	7 625	15 314
Total	12 472	24 704	37 176
BUILDINGS			
Dwellings	361	3 659	
Hotels and apartments	50	17	
Restaurants	40	6	
Factories	14	18	
Municipal buildings	9	8	
Federal buildings	4	10	
Miscellaneous	196	558	
Total	673	4 272	
TOTAL NIGHT FLOW DETECTED BY SUBDIVISION TESTS			2 072 700 gal. per day
Due to flow inside metered premises		388 700	gal. per day
Due to flow inside unmetered premises		564 600	gal. per day
Due to underground leakage			
Services	397 500		gal. per day
Mains	59 600		gal. per day
Unclassified	800		gal. per day
Total		457 900	gal. per day
Due to municipal consumption		52 000	gal. per day
Due to federal consumption		490 500	gal. per day
TOTAL FLOW ACCOUNTED FOR			1 953 700 gal. per day
TOTAL FLOW UNACCOUNTED FOR			119 000 gal. per day

DISCUSSION.

MR. FRANK L. FULLER. Did the water takers coöperate with you in the work you were doing, and was their coöperation necessary?

MR. LANHAM. In our work on the night test, we had no way during that night test to have access to the houses.

MR. FULLER. You could have notified them, couldn't you?

MR. LANHAM. We determined a leak inside the premises by the aqua-phone inspection at night, and the next day the inspector went back to that house to determine whether that was due to an underground leak between the curb stopcock and the house, or to some fixture within the house. If it was a leaky fixtu e, or something that could be repaired, notice was served on the owner to have it fixed. If it was simply a running faucet, careless waste, we had no remedy, as nobody could attempt to follow it out.

MR. FULLER. I suppose you could make some estimate, couldn't you, of the amount that was running?

MR. LANHAM. We had to make an estimate of the water running from our test of the night before. Our inspector used his judgment to a large extent to determine whether that flow was sufficient to account for the flow charged against that service. In the case of a heavy flow on the night test, and the finding of an insignificant leak on the premises, it would be obvious that there was some other cause, and in that case we would proceed to eliminate the leak inside of the house to see if there was an underground leak on the pipe, which would not, of course, be heard until the other was eliminated.

MR. DOW R. GWINN. What percentage of the service pipes are metered in Washington?

MR. LANHAM. I think they had about 75 per cent. metered, but there have been some 10 000 meters taken out for repairs.

MR. GEORGE H. ABBOTT. Have you ever had any experience with Darley's leak detector?

MR. LANHAM. We have used some of the more sensitive microphones, and the inspectors seem to prefer the aqua-phone. My personal experience has been practically all with the aqua-phone. The use of the sonoscope, and some of those other sensitive instruments, was tried after I came out of the field, and I am going more on the opinion of the inspectors than on my own experience in that matter.

MR. ABBOTT. Have you ever had any experience with the geophone?

MR. LANHAM. I have heard of the geophone, and I am going to make experiments with it shortly.

MR. S. H. MACKENZIE. Have you ever used the instrument that was put on the market by Darley of Chicago?

MR. LANHAM. No, sir. I have seen that advertised.

MR. MACKENZIE. You would really have to get somewhere near the pipe to detect the leak?

MR. LANHAM. It is a listening device, isn't it?

MR. MACKENZIE. Yes, it is a listening device.

MR. LANHAM. We have not tried that.

MR. MACKENZIE. How near do you calculate you have to get the iron point to the main to use the aqua-phone?

MR. LANHAM. We actually get the iron point against the main in using the aqua-phone.

MR. W. C. HAWLEY. I have used the instrument put on the market by Darley, and we found it very satisfactory. It cannot be used in the vicinity of streets on which there is heavy traffic. There are other noises to confuse. It is a very satisfactory instrument. We use it to detect leaks under concrete, and it has very interesting results.

MR. E. G. REYNOLDS. I have had the same experience with the Darley instrument. It is very good in detecting the leak. But after you know you have the leak you must find the particular spot, and we have to make about ten cuts in the permanent pavement and get down to the main and get the sound on the main. The sound grows louder as you near the point of break, and then as you pass it the sound gets fainter. The instrument is very sensitive, and you can't use it in the wind. You have to put the covered box on it.

MR. LANHAM. Have you any data on the size in gallons per day of the leak and the size of the main?

MR. REYNOLDS. This was on an 8-in. main. I do not know the number of gallons it was running.

MR. LANHAM. The work in Washington has worked down to the question of finding leaks of 300, 400, or 500 gal. per day, which are very difficult to find, and I was wondering whether the instrument you spoke of had ever been employed in the detection of small leaks.

MR. REYNOLDS. We use it more to determine the point of leakage. We are not searching for leaks with the Darley instrument.

MR. LANHAM. It has a similar use to the aqua-phone instrument. We know the leak exists and then we proceed to look within the limits where that leak is, with either the aqua-phone, or possibly we could use an instrument of the Darley type, although I have not as yet.

MR. A. P. FOLWELL. Is it necessary with the Darley instrument to get the sounder down on the main, or can you locate it by traversing the surface of the street?

MR. REYNOLDS. No, you do not go down. You lay it on the surface of the street. You do not dig into the street at all.

MR. FOLWELL. That is very interesting to me. A great percentage of our leaks are under a hard surface, very expensive indeed to dig up. If we can do that I will send for a Darley.

MR. D. A. HEFFERNAN. In my paper about a year or two ago I dwelt on this Darley machine on underground service pipes. The Darley machine I used on inch and a half pipe, and using the pipe locater — of course, this was a private service, 1½-in. pipe, and the service was about 1 000 ft. long, and we used the pipe locater first and located the pipe, and then took the Darley machine and went up the line, and in about 500 ft. got the sound of the leak. I told the laborer to dig down at this point, and he dug down and there was the leak on the first dig.

MR. LANHAM. I am willing to concede that the Darley machine is all right. We have had many endorsements of it, and the Darley machine will soon be in use in Washington.

MR. HEFFERNAN. The size of the leak perhaps would determine whether you could hear it with the Darley machine or any machine. Has your experience indicated that the nature of the leak has as much to do with it as the size?

MR. LANHAM. I think it is a case of the velocity. If you have the pipe wide open there is no greater velocity at the end of the pipe than there is through the whole pipe; therefore you do not get any sound.

MR. HEFFERNAN. If the pipe was broken off where it went through the manhole you probably could not detect it.

MR. LANHAM. There would not be any appreciable difference between the sound at the end of the pipe and all along the pipe. You have to pick out your leak sounds from the other sounds on the main. It is purely a case of the relative size of the aperture, I should suppose, in regard to the size of pipe the main supplies. If the pipe is large you get a low velocity up to the leak point, and the aperture produces a high velocity.

MR. HEFFERNAN. Before going into a district for the first time and making a survey, do you send somebody around to test all the gates, the service cocks, so as to be sure they are shut off, or do you wait until you get on the ground?

MR. LANHAM. In the work I have done, we have started the work and tried to get the valves in condition as we went along. We have done no advance work except in the matter of stopcock detection. When we have men idle we send them far ahead on the stopcock detection. In the case of Washington, the work of valve examination is all taken care of by another division of the department. We can almost count on the valves being 100 per cent. perfect. We have an entire division of valves, and they are kept in perfect condition. But in some of the work I have done in other cities, I have run into difficulty with the valves, and we have had to stop work and go into other sections and get repairs made.

MR. FRANK L. FULLER. May I ask if you get the cöoperation of the water users?

MR. LANHAM. We do not consider that. We have simply gone ahead with our tests, and where we found leaks in the houses we gave notice to have them repaired. We have served notice that the water would be cut off in forty-eight hours if they did not make repairs.

MR. FULLER. Don't you get a lot of kicking?

MR. LANHAM. Fortunately, we do not get the kicking. We serve the notice and send a copy of the notice to another branch of the department, and all the kicking is made to that branch.

MR. E. G. REYNOLDS. I have noticed in some of your reports from Washington that a great percentage of these losses occur on the service lines. I should like to know if these are actual leaks on the service mains. What percentage of the loss in the

service line is chargeable to an actual break in the service line? In other words, in our plant we are practically 100 per cent. metered, and all the water that goes through that meter would be paid for. It might be all waste water. Now, do you make any distinction in your paper between waste and water leakage?

MR. LANHAM. All of these figures given in my report are underground leakage unless it is clearly stated otherwise.

MR. REYNOLDS. I notice that about 60 per cent. of the underground leakage was on the service lines.

MR. LANHAM. Yes. Our biggest percentage of leakage has been for years, and I think every year, in the service pipes. In Washington a great quantity of the service pipe was iron pipe, and that has corroded badly, and we have found as many as six leaks on one pipe year after year.

MR. S. H. MACKENZIE. Do you use lead flange or wiped joints?

MR. LANHAM. Wiped joints have been used on the gates in the case of practically all the Washington works, but I believe now they are using lead flanges. I think we have found a few cases of lead flanges, but it is not a fair comparison of the relative advantages of the wiped joint and the lead flange, because of the relatively small number of lead flanges now in use.

WATERSHED LEAKAGE IN RELATION TO GRAVITY WATER SUPPLIES.

ROBERT E. HORTON.

INTRODUCTION.

Probably every one has noticed the apparent difference in yield sometimes occurring in the case of small adjacent similar drainage areas. When the precipitation, soil, and cultural conditions for such areas are similar, the difference in yield is no doubt often due to watershed leakage.

Watershed leakage may be defined as the passing of waters underground from one topographic drainage basin into another. The area tributary to a stream at any point may be considered as the drainage basin at that point. Watershed leakage often occurs from the upper to the lower portions of the same drainage basin, that is to say, some of the waters naturally tributary to the stream, above a certain point, do not enter the stream above the point, but pass underground into the stream at some lower location.

Watershed leakage may also be defined as a condition where the boundary of the ground-water horizon supplying the stream is not coincident with the surficial watershed line. Nearly all large artesian systems involve watershed leakage, but this discussion will be mainly limited to its occurrence in conjunction with the surficial ground-water horizon.

Watershed leakage from the upper to the lower portion of the same drainage basin, or from the lower portion of a tributary to the stream it enters, is commonly called " underflow " in the West. Its occurrence requires that the ground-water horizon shall lie below the level of the stream bed. In such cases water may be lost from the stream directly by percolation from the stream bed, or there may be no such loss, since the bed of the stream frequently becomes watertight or impervious as a result of the silting up of the pores in the stream bed material.

A stream channel of this character has been described by

O. E. Meinzer as an "insulated stream." If there is loss from the stream channel, all the water may disappear during the dry season and the stream become intermittent in a given reach, having a visible or surface flow only during floods, such run-off as occurs at other times being in the form of underflow. This condition is a common one on rivers of the plains.

Watershed leakage on a large scale, in the case of plains streams, or underground rivers in limestone regions, is obvious, It is the occurrence of similar conditions on a small scale, where the phenomenon is not obvious, or might not even be suspected, to which attention is especially called. As will be pointed out, watershed leakage, of sufficient extent to seriously affect the accuracy of estimates of stream yield or run-off, is more likely to occur in conjunction with the basins of small streams than in conjunction with larger rivers.

Many gravity water supplies, and some high head power developments and irrigation systems, are dependent on the yield of relatively small drainage basins, which often lie at high elevations. Rainfall records in such basins and gagings of the yield of such small areas are much less common than in the case of large drainage basins, and in estimating the available yield it is frequently necessary to depend upon studies based on rainfall and water losses, gagings of other streams, or these data in conjunction with limited gagings of the stream in question.

On account of the simplicity and uniformity of conditions commonly prevailing over the area tributary to a small stream, gagings of the run-off from small areas should afford valuable data for the determination of the laws of stream flow. Conversely, it should be possible to estimate the water losses from such small areas more readily and accurately than in the case of large areas with complex and diversified soil and cultural conditions. In either case it is necessary, in order that the results may be correctly applied, that the basins under consideration should not be affected by watershed leakage.

In view of the considerations which have been presented, it appears that when any small drainage basin is proposed as a source of upland or gravity water supply, or for similar uses, where watershed leakage is liable to occur, the yield should be

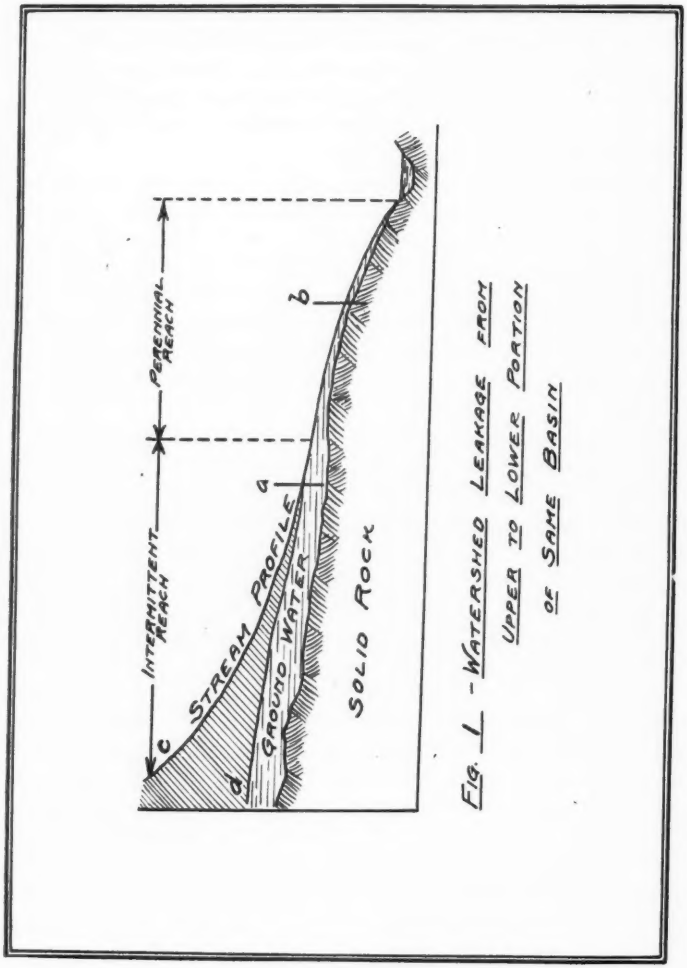


FIG. 1 - WATERSHED LEAKAGE FROM UPPER TO LOWER PORTION OF SAME BASIN

determined by gagings, if possible. In the absence of a long-gaging record, measurements during a dry period, in conjunction with observations of rainfall, are very desirable. If the occurrence of watershed leakage is suspected, the drainage basin should

be examined with reference thereto. During high water, watershed leakage on a limited scale may affect the run-off of a drainage basin but little, since the ratio of ground-water supply to surface run-off is then often relatively small. Gagings taken during low water may, however, show results per unit of topographic area considerably greater, or less, than those obtained from adjacent similar basins not subject to watershed leakage. A critical study of the underground water conditions may reveal evidence of watershed leakage sufficient to fully account for the apparently anomalous result of the gagings.

Conditions of Occurrence of Watershed Leakage.

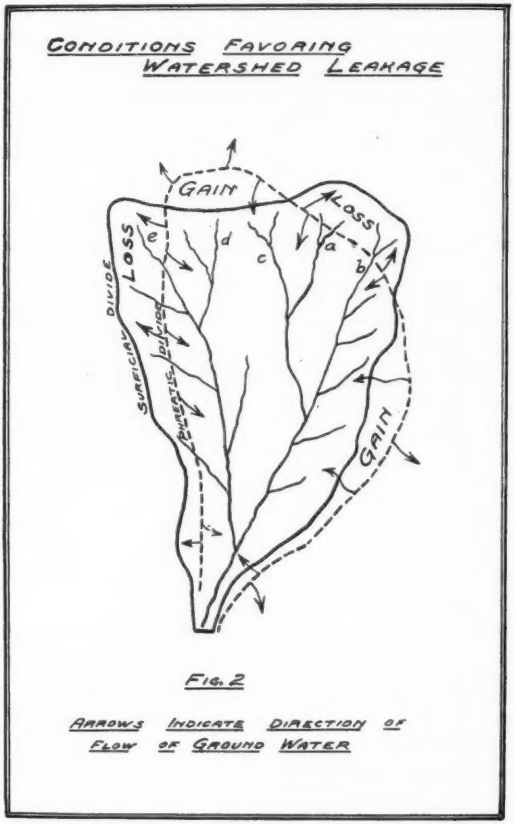
Streams or their tributaries which have no branches may for convenience be called "first-order" streams or tributaries, — those which branch once, "second-order" streams, and so on.

Nearly all first-order streams are intermittent or evanescent in their headwater reaches. The reason for this is illustrated by Fig. 1, in which $c - a - b$ represents the stream profile, and $d - a - b$ the profile of the ground-water horizon. The depth to ground water commonly increases with the height of the land. Streams near their sources, owing to their small eroding power, have not as a rule cut their channels deep enough to intercept the ground-water horizon, and are therefore intermittent, flowing only after rains or when snow is melting.

In Fig. 1 the stream shown would be intermittent above the point a, and perennial below this point. Infiltration through the soil on the area above a provides ground water which supplies the stream below a. The surface run-off of the stream above a is less than the total yield of its tributary area, the excess passing as underflow into the area below a.

Since the fingertips of the drainage net of a stream are mostly first-order tributaries, subject to these conditions, it follows that there is usually a belt surrounding a drainage basin just within the watershed line (excepting in case of very impervious areas), from which the run-off occurs partly through the intermittent surface streams and partly through the underflow of ground water to lower levels.

If the dividing ridge between two drainage basins is impermeable, there will be no watershed leakage. Watershed leakage in general only occurs where there is a continuous ground-water



horizon under both drainage basins or portions of drainage basins affected.

In general, the flatter the dividing ridge and the more sparse and infrequent the streams, the greater as a rule is the likelihood of watershed leakage. In large, flat permeable areas the topo-

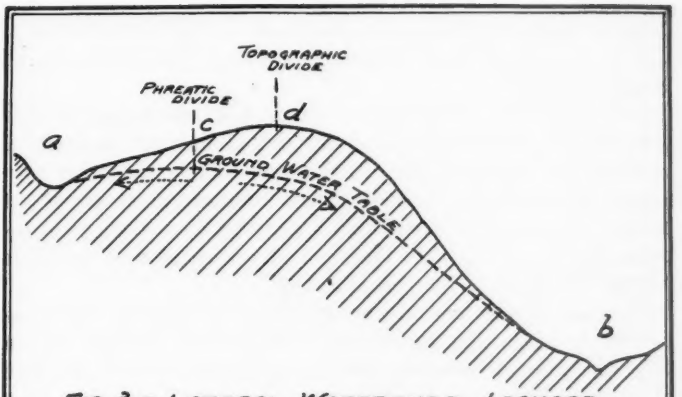


FIG. 3 - LATERAL WATERSHED LEAKAGE ACROSS A PERMEABLE DIVIDE.

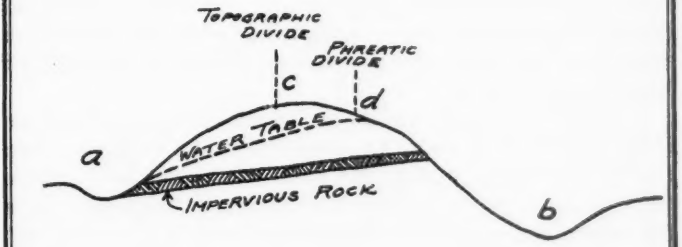


FIG. 4 - LATERAL WATERSHED LEAKAGE INDUCED BY DIP OF IMPERVIOUS ROCK.

graphic and underground water divides will frequently cross and re-cross. The run-off relations for the headwater ramifications of the river system may thus be rendered very complex, there

being inversion to one and diversion from another such tributary. Taken over the whole of a large area the local effects will often be largely neutralized.

Such conditions are illustrated by Fig. 2, in which the solid line indicates the topographic, and the dotted line the phreatic or underground water divide. In this case, taking the basin as a whole, the surficial and underground drainage areas are about equal. Some of their individual tributaries have their yield increased, as *c* and *d*, while the yield of others, as *a*, *b*, and *e*, is greatly decreased, by watershed leakage.

The ratio of the area to the perimeter of a drainage basin increases in proportion to the area. Watershed leakage from a large basin usually occurs around the perimeter, so that the effect of watershed leakage on a given percentage of the periphery of a large drainage basin is less, relative to the total yield of the basin, than in the case of a small drainage basin. The likelihood of the occurrence of opposite effects, tending to neutralize one another, is always greater in the case of large than in the case of small areas. As a result of these conditions, the occurrence of watershed leakage in a sufficient degree to materially affect the accuracy of estimates of run-off is more probable in the case of small than of large drainage basins.

A condition necessary for the occurrence of watershed leakage is the existence of an outlet for ground water at a level lower than that of the stream draining the basin from which the water is derived. If the divide between two adjacent drainage basins is not impervious, and the stream on one side has cut to a lower level than the other, the lower stream may receive watershed leakage from the higher basin. Such leakage may occur either through sand and gravel, or through non-impervious rock, such as sandstone or limestone, under suitable conditions. Figs. 3 and 4 illustrate this.

In Fig. 3 the streams *a* and *b* are parallel, and the figure shows a cross section of their valleys and of the ridge between them. While the form of ground-water table is generally similar to that of the overlying soil, under the conditions shown, the ground-water divide would generally be to the left of the topographic divide, and if the soil were permeable, the stream *b* would receive

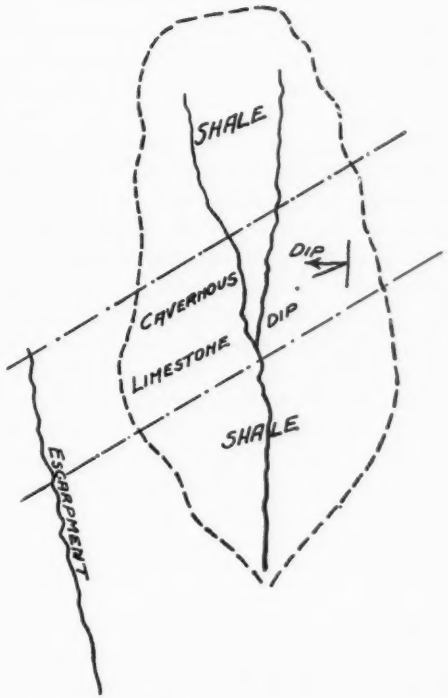


FIG. 5 - WATERSHED LEAKAGE RESULTING FROM DIP PERMEABLE STRATA.

the ground water from a strip $c - d$, the surface run-off from which is tributary to the stream a. In this case it is assumed that there are deep permeable deposits above the rock. These conditions may be reversed, as shown in Fig. 4, by the existence of impervious rock with suitable dip.

In Fig. 4, if the rock were horizontal or the deposits of permeable materials were of great depth, the conditions would be similar to those in Fig. 3. In the presence of impervious rock dipping towards the upper stream, the ground-water divide is thrown over to the right, and stream a receives the ground-water flow from a strip $c - d$ of area, the surface run-off from which is tributary to the lower stream.

Fig. 5 illustrates further the occurrence of watershed leakage due to permeable rock strata of suitable dip. Fig. 5 shows conditions existing relative to Schoharie Creek, the basin of which is crossed by cavernous limestone of the Helderberg formation. This limestone outcrops in the Helderberg escarpment at a level lower than that at which the creek crosses it. The existence of these conditions in conjunction with the notably small summer yield of the stream suggests the possibility of watershed leakage.

Fig. 6 illustrates conditions at the head of Graefenburg Creek, near Utica, N. Y. The water table underneath the hill shown lies at a depth of about ten to twenty feet. The dry run $a - b$ receives the surface run-off to the left of the line $c - d$, but this stream valley is not well developed and has not cut down to the ground water. Apparently, ground water flows in the direction indicated by the arrows, and is tributary to the perennial stream $e - f$, which originates near the foot of the steeper northerly slope of the hill.

Conditions under which small direct tributaries of large streams may lose ground water by underflow are illustrated by Fig. 7. The area directly tributary to the large stream, between the smaller streams, is the triangle $a - b - c$, but the ground water from a considerably larger area enters the main stream directly, reducing the yield of the tributaries. This condition is likely to occur around a lake margin or on a broad valley plain, filled with alluvial deposits.

An impervious rock divide will, of course, prevent watershed

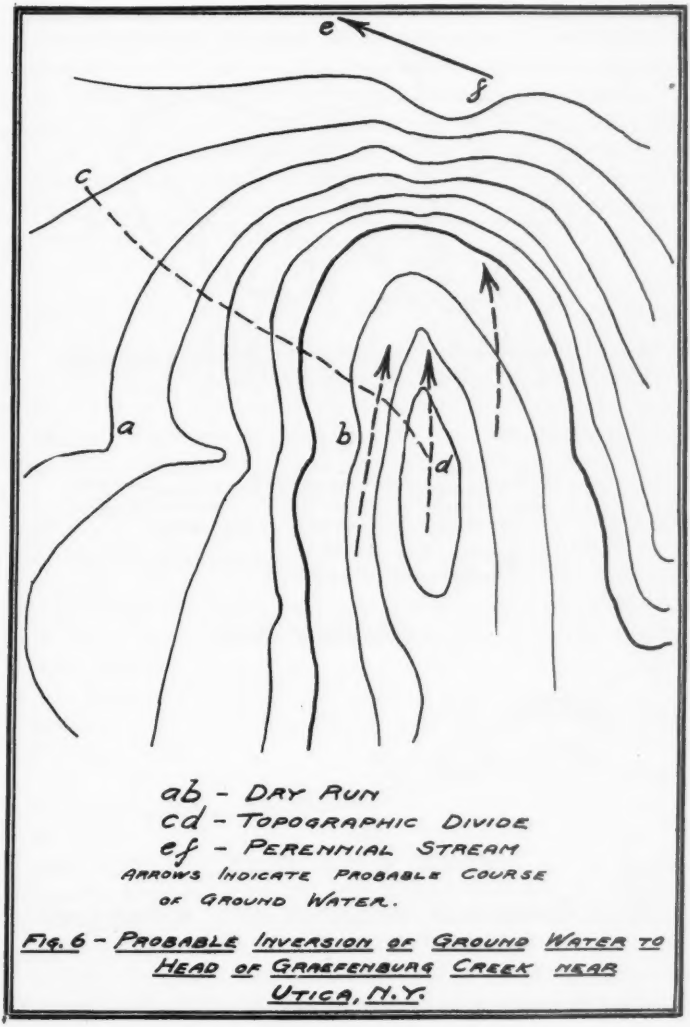


Fig. 6 - Probable Inversion of Ground Water to Head of Graefenburg Creek near Utica, N.Y.

leakage between adjacent basins, and if the soil is so shallow that there is no perennial ground water underneath the basin the effects of watershed leakage, if any, will be greatly reduced.

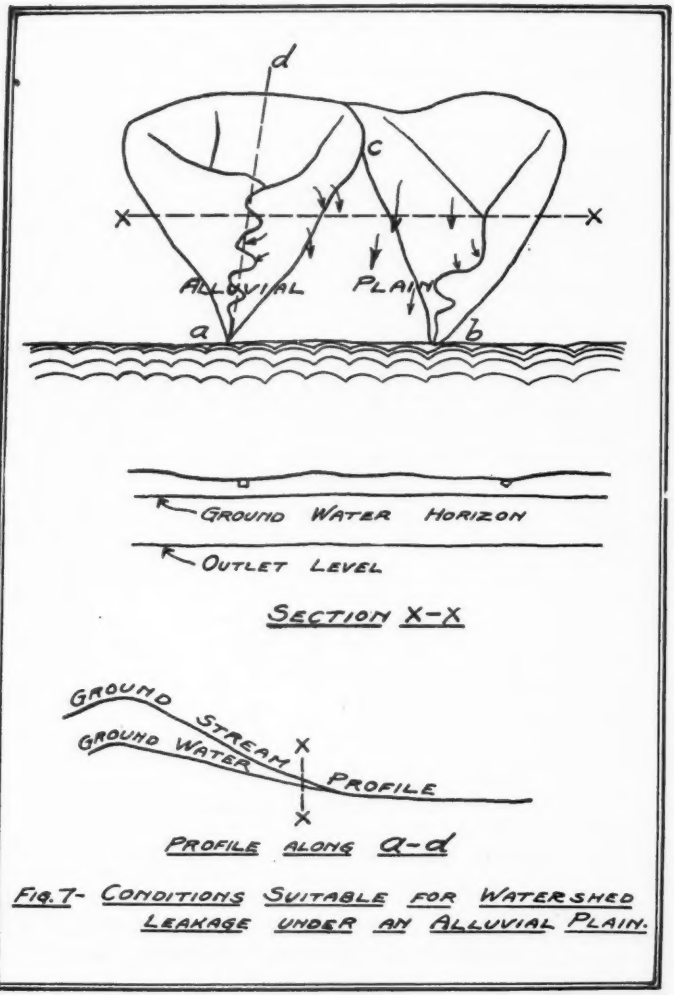


FIG. 7- CONDITIONS SUITABLE FOR WATERSHED LEAKAGE UNDER AN ALLUVIAL PLAIN.

The mere existence of rock strata in suitable position to permit of watershed leakage cannot be taken as positive evidence that such leakage occurs, since the water passages in rocks rapidly

decrease in size and number, as a rule, as the depth below the surface increases; however, in limestone regions it is possible that formations which at one time became honeycombed with solution channels have been subsequently depressed and overlain with other materials, affording opportunity for watershed leakage on a large scale. Conditions similar to these have given rise to the great springs of water in Florida, — Silver Spring, for example, which yields a constant flow of about 700 cu. ft. per second, and has but little visible tributary area.

Watershed Leakage in Regions of Deep Glacial Deposits.

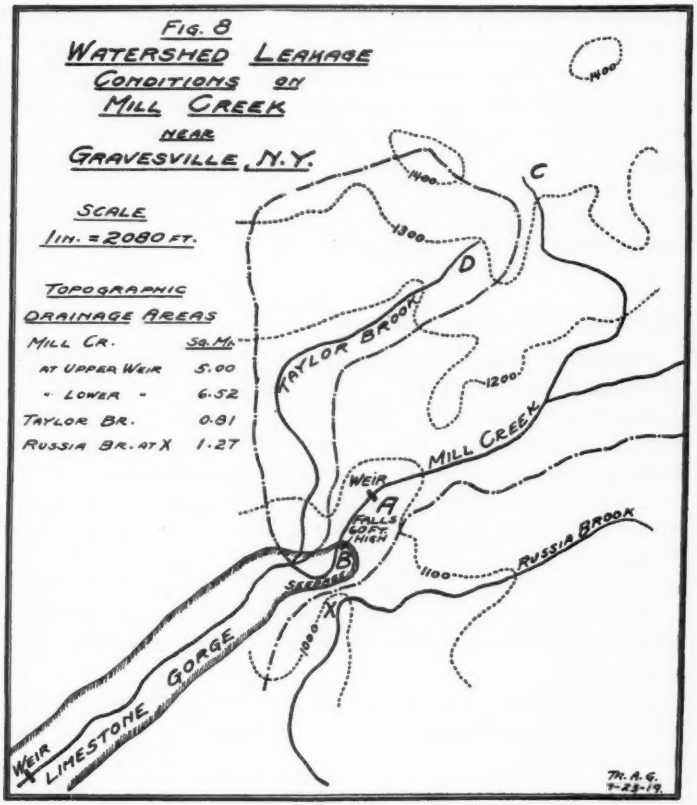
In glaciated regions the topographic drainage basin of a stream often includes numerous undrained depressions. These contribute no direct surface run-off to the stream but may contribute largely through underground flow. This constitutes sub-watershed leakage, occurring within the main drainage basin itself.

A considerable percentage of the area within the basins of the upper Kalamazoo, Grand, and Huron rivers, in the deeply filled Pleistocene deposits of southern Michigan, contributes to the streams only through watershed leakage of undrained depressions.

Small glacial lakes at somewhat different levels and separated by low divides of loose materials, often afford examples of watershed leakage.

It is common to hear the statement that a certain well, lake or stream, has no visible sources, but is spring-fed, and has an inexhaustible supply.

In a region where rainfall exceeds evaporation, no hidden or unusual source is needed to maintain a lake in a basin or depression with an impervious bottom. Precipitation on the lake surface above is sufficient. Lakes maintained in this way are usually, however, susceptible to drought, for then the supply is cut off, and the evaporation loss is usually at a maximum. In some cases lakes with no visible inflow or outflow are merely great natural wells, often of glacial origin and extending below the general ground-water horizon, — such for example as Lake Ronkonkoma on Long Island. Such natural wells may be depended upon for considerable water supplies, but such cases are



rare, and lakes or ponds having no visible sources and which must derive their supplies mainly by watershed leakage from surrounding areas, require careful investigation before adoption as sources of water supply.

WATERSHED LEAKAGE NEAR GRAVESVILLE, N. Y.

The conditions are illustrated by Fig. 8. Mill Creek and Taylor Brook drain the west slope of a group of high glacial sand hills. Both are very steady streams. Russia Brook drains a flatter sandy area to the south. Its yield in dry weather is relatively

small. The basins are all underlain by Trenton limestone, somewhat fissured, and a fall of about sixty feet occurs on Mill Creek at *B*, Fig. 8. Taylor Brook enters the gulf some distance below this fall, whereas Russia Brook comes down to within about twenty feet of the brink of the gulf, and then turns southward, not entering Mill Creek. A weir has been maintained on Mill Creek for three years, and a second weir has been maintained on the same stream below the influx of Taylor Brook and in the deep gorge below the falls. The upper weir at *A* showed a yield about equal to the normal for the same precipitation through this locality, perhaps slightly deficient. The lower weir showed a yield twenty-five per cent. greater, and somewhat above the amount that would be expected from the topographic drainage basin. Both weirs are of concrete on rock foundations with steel crests. The difference in yield at the two weirs, which are less than one mile apart, is easily accounted for from the topographic and geologic conditions.

(1) Seepage enters Mill Creek opposite the point *X*. This affords direct ocular evidence of watershed leakage from Russia Brook. This would be expected, since the surface soil is coarse sand, underlain by fissured limestone.

(2) It appears probable that Taylor Brook, which is a short stream, growing rapidly in volume, and an exceedingly good water yielder, receives underflow from a portion of the drainage basin of Mill Creek which is tributary on the surface to the branch of Mill Creek marked *C*. It is possible also that there is some watershed leakage into the area directly tributary to Mill Creek below *A*, since the surface drainage of this area is partly through sinkholes and sub-surface channels. The conditions here would

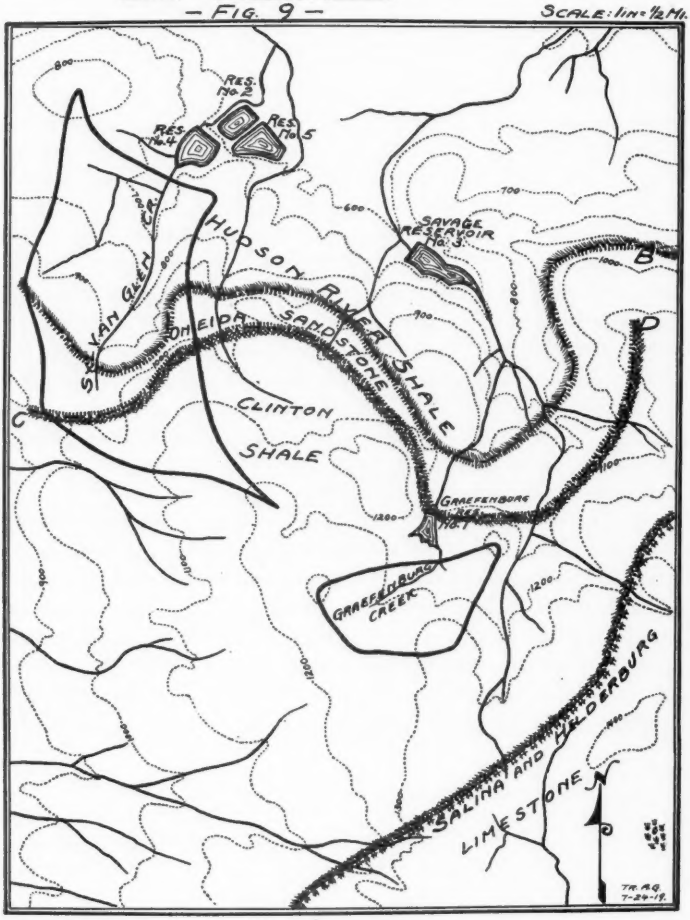
Gagings of Mill Creek at Gravesville, N. Y.

Hydrologic Year.	Precipitation.	Yield, Upper Weir.	Inches, Lower Weir.
1914–15.....	46.60	22.58	....
1915–16.....	41.71	26.37	....
1916–17.....	51.62	28.65	36.69
1917–18.....	45.18	....	35.74

TOPOGRAPHIC AND GEOLOGIC CONDITIONS IN RELATION TO WATERSHED LEAKAGE NEAR UTICA, N.Y.

— FIG. 9 —

SCALE: 1 IN. = ½ MI.



naturally be expected to produce the results found from the gagings. It will be noted from Fig. 8 that, owing to the narrow divide at *X*, diversion of Russia Brook into Mill Creek is ap-

proaching. This is hardly a true case of piracy, in the physiographic sense, since it will probably result from the cutting outward of the bend at *X* on Russia Brook rather than from aggressive action of Mill Creek; still it illustrates an apparently general principle: that stream piracy is usually preceded by subdiversion.

Sylvan Glen and Graefenburg Creeks.

The location of the drainage basins and the underlying geologic conditions for these streams are shown by Fig. 9. The drainage basin of Sylvan Glen Creek is practically all underlain by Hudson River shale, extending to a great depth, and which contains little or no ground water. The average elevation of this basin is about 700 ft. above tide.

Graefenburg Creek Basin is underlain by Clinton shale which is not quite so compact and impervious as the Hudson River shale. This basin is at an average elevation of about 1 200 ft. above tide.

Referring to the accompanying Table 1, it will be noted that the mean depth of run-off, for five years, of Graefenburg Creek is much greater than that of Sylvan Glen Creek. Taking the averages by individual months, it is found that the run-off depths of the two basins are practically equal in the flood months March and April. Sylvan Glen Creek is very nearly dry during midsummer months, whereas the average yield of Graefenburg Creek in the midsummer months is about 1.5 in. per month. Two rainfall records are given, both taken with standard Weather Bureau gages. The one at the Savage Reservoir, elevation 700, shows six inches greater precipitation than the one at Graefenburg. On the face of the records, the higher run-off corresponds to the lower precipitation. These apparently anomalous results are readily explained, for the most part, by the fact that examination of the drainage basin shows an outcrop of Salina and Helderberg limestone adjacent to the Graefenburg area, from which large springs issue and enter Graefenburg Creek.

In the case of Sylvan Glen Creek, the stream is commonly dry during the summer months, a little distance above the weir, where it flows over solid rock. The weir is, however, located on a delta plain below the mouth of the rock gorge and there is evi-

TABLE 1.

Comparison of Measured Yield of Sylvan Glen and Graefenburg Creeks near Utica, N. Y.

Annual Yield.

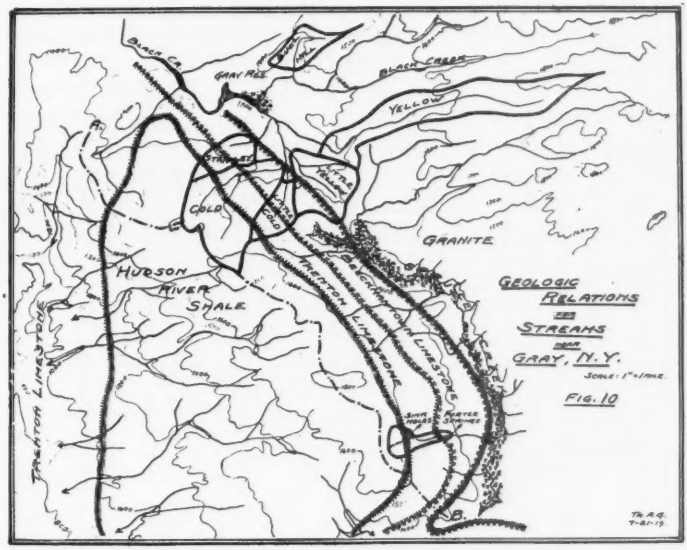
Year.	Precipitation.			Annual Yield, Inches, Depth.	
	Savage Res.	Graefenburg Res.	Deerfield Res.	Graefenburg.*	Sylvan Glen.†
(1)	(2)	(3)	(4)	(5)	(6)
1908.....	36.28	31.49	33.19	30.06	13.54
1909.....	43.12	37.52	36.07	27.65	21.77
1910.....	43.64	35.94	40.70	27.70	17.35
1911.....	44.18	36.99	40.23	26.46	17.98
1912.....	46.25	39.79	35.65	32.51	24.50
Average...	42.69	36.35	37.16	28.87	19.03

Monthly Average Yield, Five Years, 1908–1912.

Month.	(2)	(3)	(4)	(5)	(6)
Jan.....	2.64	2.11	2.23	2.33	1.82
Feb.....	3.43	3.12	2.87	2.66	2.07
Mar.....	2.62	2.44	2.18	4.73	4.60
Apr.....	3.15	2.84	2.84	4.27	4.61
May.....	4.77	4.38	4.41	2.70	1.68
June.....	4.04	3.04	3.68	1.83	0.56
July.....	4.11	2.73	3.19	1.48	.064
Aug.....	3.88	3.35	3.22	1.45	.078
Sept.....	5.93	4.93	4.48	1.78	.494
Oct.....	3.54	2.90	2.90	1.66	.466
Nov.....	3.26	2.61	2.73	1.97	1.13
Dec.....	2.52	1.91	2.45	2.04	1.46
Year.....	42.69	36.35	37.17	28.9	19.03

* 0.35 sq. mile, formerly taken as .281 sq. mile.
† 1.18 sq. mile.

dence of some loss of water by underflow. These conditions account for the differences in yield, regardless of rainfall. As to the rainfall, the Savage or lower gage is on a steep northerly slope, well protected from south and west winds but possibly receives more than its true precipitation, owing to eddying effect of the wind blowing over the crest of the slope. The Graefenburg



Reservoir gage is on a high plateau, freely exposed to the sweep of the wind, and undoubtedly records less than the true precipitation.

These conditions and records illustrate the difficulty of estimating the yield of small drainage areas from limited data, and emphasize the necessity of taking into account all the surrounding conditions.

Conditions of Streams Tributary to Gray Reservoir.

Weir measurements have been kept for ten years on each of five small streams tributary to Gray Reservoir in Herkimer County, N. Y. The location of the drainage basins relative to

TABLE 2.

CHARACTERISTICS AND YIELD OF STREAMS TRIBUTARY TO GRAY RESERVOIR, HERKIMER, N. Y., NOVEMBER, 1908, TO OCTOBER, 1918, INCLUSIVE — TEN YEARS.

Stream.	Area Sq. Mi.*	Culture — Per Cent.				Underlying Rock.	Elv. Head of Basin.	Elv. at Weir.	Mean Slope, Ft. per Mile.	Precipitation, Inches.	Measured Yield, Inches.			Apparent Water Losses.
		Open Swamp.	Wooded Swamp.	Highland Woods.	Meadow.						Nov. — April.	May — Oct.	Year.	
(1)	(2)	(3)				(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Yellow Brook	2.12	0	5	90	5	Granite	1 500	1 330	350	48.61	22.44	12.69	35.13	13.48
Little Yellow	0.766	0	70	25	5	Gr. 75% Ls. 25%	1 860	1 330	300	48.61	23.70	11.59	35.29	13.33
Stanley	0.469	0	10	5	85	Sh. 5% Ls. 85%	1 510	1 330	250	48.61	19.90	12.48	32.38	16.23
Cold	1.353	5	20	10	65	Sh. 60% Ls. 40%	1 550	1 340	250	48.61	20.48	11.21	31.69	16.92
Little Cold	0.798	10	20	30	40	Sh. 15% Ls. 85%	1 700	1 380	250	48.61	21.56	11.35	32.91	15.71
Bull Hill	0.332	5	15	10	70	Granite	1 600	1 330	330	48.61	....	....	31.65†	....

* From transit survey of watershed.

† 1908–13.

the underlying geologic formations are shown in Fig. 10, and the areas of the drainage basins and the characteristics in measured yield in the different streams are shown by the accompanying Tables 2 and 3.

The weirs are of similar construction, of concrete, with steel crests, and all readings were taken by the same observer. The tributary areas were determined by transit survey of the watershed lines. It will be noted that the two streams draining granite areas show about three inches greater yield per year than the streams draining areas underlain by limestone and shale. The streams on granite areas contain larger percentages of woods than the others.

At first sight, the larger annual yield of the wooded granite areas might be attributed to the conservation of water by the forests. This, I think, is not the case. The grass areas quite certainly consume less water in vegetative processes than do the

TABLE 3.

RELATIVE YIELD OF GRAY, N. Y., STREAMS ON GRANITE AND LIMESTONE FORMATIONS, 1908–1918 INCLUSIVE.

	Granite Areas, Yellow and L. Yellow.	Limestone Areas, Cold, L. Cold, and Stanley.
	Inches.	Inches.
January	2.50	2.36
February	2.74	2.36
March	3.74	3.39
April	7.28	5.57
May	3.18	2.63
June	1.62	1.64
July	1.14	1.24
August	0.83	1.10
September	1.40	1.36
October	2.23	2.05
November	2.60	2.27
December	2.04	2.00
Year	31.32	27.97
Means	2.61	2.33

forests. Furthermore, the difference in yield occurs mainly in the winter time, the apparent water losses in the granite and limestone areas being very nearly equal in the summer season, such differences as do exist being readily attributable to cultural conditions.

Spruce Creek adjoins the streams underlain by limestone on the south and at a level considerably below their basins. The outcrop of the limestone belt is at nearly uniform level. There are numerous sinkholes in this limestone, the location of some of which are shown on the map, Fig. 10.

It seems most probable that Stanley, Cold and Little Cold brooks lose some water in the underlying limestone, very likely part of this loss going northward into Black Creek, and part going southward into Spruce Creek, drainage basin. Apparently the excess of the water consumption in the summer season on the wooded granite over that of the more open areas underlain by limestone is just about sufficient to balance the watershed leakage from the latter areas.

Evidence of Watershed Leakage in the Watuppa Pond Area, Fall River, Mass.

Gagings of nine small streams, tributaries of North Watuppa Pond, Fall River, Mass., by Arthur T. Safford, C.E. (Report of the Reservoir Commission to the City Council of Fall River, 1902), covering the three complete years 1899 to 1901, show wide variations in run-off and water losses.

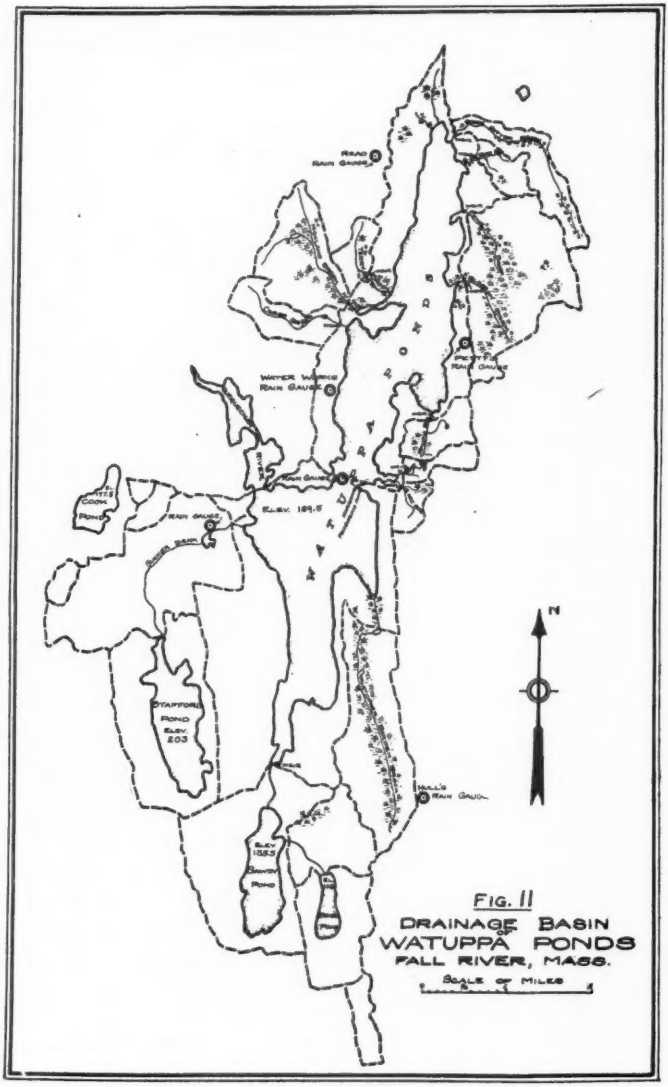
The locations of the drainage basins and rain gages are shown in Fig. 11. The subjoined Table 4 gives the physiographic characteristics of the different drainage basins. The outflow from North Watuppa Pond was also measured at the narrows. The evaporation was measured by a tank 5 ft. 11 in. in diameter and 3 ft. high, at the narrows gaging station. The tank was 2.25 ft. above water surface for the full pond. Water in the tank was 6.9 in. below the rim. This would indicate a large reduction due to rim factor, and it is probable that the measured evaporation from the tank was about equal to the actual evaporation from the water surface, since the effect of the rim factor would approximately compensate for the difference between surface temperature in

TABLE 4.

CHARACTERISTICS AND YIELD OF TRIBUTARIES OF NORTH WATUPPA POND, FALL RIVER, MASS., 1899 TO 1911. (ARTHUR F. SAFFORD.)*

Stream.	Area, Sq. Mile, at Weir.	Woods. Per Cent.	Culture. Per Cent.	Swamp. Per Cent.	Mean Precip. 3 Yrs. Inches.	Meas'd Yield, 3 Yrs. Inches.	Apparent Water Loss. Inches.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cress Brook	0.466	.....	90 Meadow	0	44.43	10.97	33.46
Highland Brook	1.082	20–30	50	20–30	44.43	27.47	16.96
Terry Brook	0.218	20–30	50–60	10–15	44.43	29.47	14.96
Queen Gutter Brook	0.629	80±	Little	10–15	44.43	17.07	27.36
Run Brook	0.195	80 (Cut over)	Little	2	44.43	14.43	30.00
King Philip and Blossom	2.144	33	Little	66⅔	44.43	23.65	20.78
Ralph Brook	0.337	75	15	10	44.43	14.82	29.61
North Nat Brook	0.211	40 (Heavy)	60 Meadow	0	44.43	10.79	33.64
South Nat Brook	0.164	.....	75 Meadow	0	44.43	20.32	24.11
Mean of all	5.446	.....	.....	.....	44.43	.....	.....

* Report of the Reservoir Commission, 1902, Fall River City Council.


RAND
RAIN GAUGE
WATER WORKS
RAIN GAUGE
RAIN GAUGE
ELEV. 191.5
RAIN GAUGE
STAFFORD
POND
ELEV.
203
N
FIG. II
DRAINAGE BASIN
OF
WATUPPA PONDS
FALL RIVER, MASS.
SCALE OF MILES

the tank and pond and for the vapor blanket effect on the broad lake surface.

The weirs were of standard construction, and the tributary areas were determined by survey. Correcting the measured outflow from the pond for the difference between precipitation and evaporation on the water surface, Safford found that the average yield of the total area above the narrows for the three years was 18.1 per cent. greater than the average yield for the same years as indicated by the gagings of the upland areas.

The presence of open spots in the ice on the pond in winter indicates springs entering the pond. There are also some springs and seepage areas on the tributary stream basins. Mr. Safford concludes that there is certainly no inversion to the drainage basin as a whole, and that the entire outflow from the north pond results from precipitation on the tributary area. The table of results shows generally the largest run-off and smallest apparent water losses for the low-lying drainage basins which are flat, wooded and swampy. This relation holds generally for the three individual groups of streams. Only two streams show measured run-off greater than the corrected average inflow from the land area as determined from gagings at the narrows. There is evidence of watershed leakage from the higher to the lower-lying streams in the different groups, but apparently the major portion of watershed leakage takes place from the individual areas directly to the pond.

Streams Adjacent to Pike's Peak.

Water Supply Paper No. 437, United States Geological Survey, contains results of gagings of streams on the east slope of Pike's Peak and adjoining mountains in Colorado, for the period October, 1909, to September, 1916, inclusive.

In most instances, the differences in yield of these small adjacent drainage basins are no greater than would be expected from the differences in elevation and cultural conditions. Lyon, Sheep, and Cabin creeks drain narrow parallel basins, heading on Pike's Peak, and are all tributary to South Ruxton Brook. There is a crater toward the head of Sheep Creek basin which it is stated is

probably tributary to Lyon Creek, and the surface area above this crater has been excluded from Sheep Creek basin and included in Lyon Creek basin. The figures in Table 5 show, however, that on this basis the apparent water losses for Lyon Creek are four inches, or fifty per cent. greater than for Sheep Creek, so that the correction does not appear to be justified, and a detailed geologic study would be necessary to harmonize the results, although in view of the close identity of form, elevation, culture and exposure of these two basins, it appears that the areas actually tributary to them must be very nearly proportional in their yield.

Detection of Watershed Leakage.

The writer has felt that the practical utility of geology as an aid to engineering could be materially increased, especially along hydraulic lines.

The detection of watershed leakage affords an opportunity for the use of geologic knowledge in the interpretation of stream-flow records. Cases where watershed leakage is suspected are very numerous. There are not many instances, however, where sufficient data for full determination of the question are available. Such determination requires in general actual gagings of the stream in question; furthermore, gagings of other streams are needed for comparison, so that the relation of the measured run-off or water losses to the normals for a similar drainage basin, free from watershed leakage, can be determined. In general, water losses are less variable than either precipitation or run-off, and conclusions based on comparisons of water losses are therefore more reliable.

A map of normal water losses for a region would be a valuable aid in such studies, and could be used in a manner similar to the use of maps of normal chlorinal content, in the study of water analyses. The writer has such normal water-loss maps for the eastern United States in preparation. If a study of the run-off and water losses of a given drainage basin indicates that these are abnormal, and suggests the probability of watershed leakage, a geologic study of the drainage basin may be made. It is difficult to lay down satisfactory general rules for such a study. Obviously

TABLE 5.

HYDROLOGIC DATA, STREAMS NEAR COLORADO SPRINGS, 1909–16 INCLUSIVE.

Stream.	Square Miles.	Per Cent. of Area Below Timber Line.	Slope of Axis.	Azimuth* of Axis.	Mean Elv. of Basin.	Summer.			Winter.			Year.		
						P.	Y.	L.	P.	Y.	L.	P.	Y.	L.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Boehmer Creek.	7.20	25 Sparse	.068	S45°W	11 750	17.06	8.47	8.59	8.46	2.28	6.18	25.52	10.75	14.77
Little Beaver Creek.....	1.00	75 Sparse	.180	N80°E*	11 750*	17.06	7.95	9.11	8.46	.86	7.60	25.52	8.81	16.71
Sachett Creek ..	0.65	70 Sparse	.130	S7°E	11 650	17.06	9.05	8.01	8.46	.73	7.73	25.52	9.78	15.74
Lyon Creek....	2.00	70 Sparse	.262	N80°E	11 450	17.06	5.05	12.01	8.46	2.86	5.60	25.52	7.91	17.61
Sheep Creek....	0.73	100 Sparse	.190	N80°E	10 400	17.06	8.99	8.07	8.46	3.00	5.46	25.52	11.99	13.53
S. Ruxton Creek	3.95	100 Heavy	.170	N44°E	10 600	17.06	5.91	11.15	8.46	2.07	6.39	25.52	7.98	17.54
Cabin Creek....	2.40	85 Sparse	.246	N80°E	11 400	17.06	7.27	9.79	8.46	1.90	6.56	25.52	9.17	16.35
Average.....	...	.....	...	.....	.....	17.06	7.53	9.53	8.46	1.96	6.50	25.52	9.48	16.04
Lyon-Sheep-Cabin†.....	5.13	80 Sparse	...	.....	.....	17.06	6.66	10.40	8.46	2.79	5.67	25.52	9.45	15.07

* Approximate. † Weighted average.

the character, uniformity, and depth of the soil overlying the basins, as well as the dip of the underlying rock, are important.

Since the existence of a stream channel perched above the surficial ground-water horizon nearly always accompanies watershed leakage, in the form of subdiversion, a study of the depth of the ground water in wells in regions in which the loss of water is believed likely to occur may be helpful.

In investigating the likelihood of watershed leakage, especially in small drainage basins such as are used for gravity water supplies, the following suggestions may be useful:

(1) Watershed leakage is always from a higher to a lower drainage basin. In case of inversion, higher-lying adjoining areas should be examined. In case of diversion, the presence of lower-lying adjoining areas which may afford an outlet for the water losses should be looked for.

(2) Aside from loss through solution channels in limestone regions, watershed leakage usually occurs only where there is a continuous ground-water horizon. It does not occur where there is an impervious rock barrier forming the boundary between the two areas in question.

(3) Watershed leakage is more likely to occur between areas overlain by deep beds of sand, gravel or porous glacial deposits than between areas with less permeable soils or with rock near the surface. It is more likely to occur in regions underlain by limestone and sandstone than in regions underlain by shale or granite. It is more likely to occur through rocks of moderate dip than through horizontal strata, — and it is more likely to occur through broken, seamy and fissured rocks than through compact, uniform beds of rock.

(4) It is more likely to occur between basins with low, poorly marked watershed divides than between steeper areas. The configuration of the surficial ground-water table generally follows closely that of the overlying topography, and the topographic forms, as well as the geologic conditions, should be taken into account.

Summarizing. — The shallower the soil mantle, and the closer to the surface the rock, the steeper the slopes, and the more impervious the soil and rock, the less is the likelihood of serious watershed leakage.

Discussion.

Mr. W. A. MacKenzie. Mr. Horton's paper has been a mighty interesting one to me, and, besides, he has brought out some very valuable data on a subject which I think has been neglected somewhat, perhaps, and it shows conclusively that the run-off from one watershed is not a criterion to go by in considering the run-off from another watershed, although its topography may be about the same.

This has been brought out somewhat in a matter which we have under consideration, where two weirs were beside a watershed of about one square mile in area, and during the six months' dry-flow the run-off from the upper area was about 30 per cent., I believe, less than the run-off from the lower, showing conclusively that in making a study for water-works development this should be more fully considered in locating the pond area, or the dam, and that if this were more fully considered perhaps better results would be obtained, and sometimes we would consider more fully the location of the dam, not overlooking perhaps in some cases the fact that a larger expenditure for a dam in a different location would bring about much better results and a larger yield for that area.

I know, in talking over the possible damages in this particular area with another engineer on the other side, we suggested this, and he said that this theory had been exploded long ago. He maintained that we were not getting the full benefit of this upper section, where we might build the dam. But our weir measurement for two years or more conclusively showed that we could not obtain the full advantage. I should like to ask Mr. Horton if this has ever been brought out in court cases on the payment of damages on the diversion of watersheds, and whether they have been able to prove, and it has been accepted and the award perhaps based somewhat on the watershed leakage.

Mr. Horton. I do not know of this question having come up, — of watershed leakage in any diversion damage cases.

Mr. L. M. Hastings. I have been interested very much in the paper. I think it is a very important subject, especially if we are considering the yield of the drainage area.

I could not help thinking of our own experiments in Cambridge, where about twenty years ago we had a development of a large watershed, about 23 square miles, and on that watershed had a secondary dam which controlled the water over about 7 square miles. This water flowed into the larger area, which was located on the upper reaches of the streams. Precisely the condition which Mr. Horton so well described took place there while we had the matter under consideration.

In the summer of 1896 or 1897, while we were building that dam, the flow from that stream practically dried up, whereas the flow on the entire 23 square miles of area maintained a fairly good yield of water, showing that for the dry weather flow, at any rate, the smaller stream in proportion to the entire watershed gave a very much smaller yield than the entire shed. I think the most casual examination of the yields of watersheds will show that fact, — that the smaller the watershed the less the yield will be and the greater the fluctuation. That is, the summer flows seem to be smaller in relation to their size in the small streams than in the larger ones. While the Merrimack River will give a steady flow, relatively speaking, through the entire season, a small, secondary portion of the yield of that watershed will give a very small yield.

In the case of the Cambridge supply in the city of Waltham and town of Lincoln, in Massachusetts, the total yield for the year on the smaller streams was very much less than the ratio of the whole 23 square miles. So that I think in trying to obtain a water supply for any community the larger the stream the more uniform and larger in extent will the flow be.

This is a well-known fact in water-power development, — the larger stream is more uniform in flow and more power is obtained. Of course if the drainage areas are small compared to the storage basin that difference diminishes, because in a degree you can carry over your storage from the heavy flow of the winter and spring. But ordinarily I think it has been found that the smaller the drainage area the smaller the practical results are that you can obtain from it.

Mr. Lincoln Van Gilder. I should like to ask Mr. Horton a question. This is in reference to our own development. We have a watershed at my city of about 18 square miles, all sand,

and covered almost entirely with scrub timber of oak and pine. The lower part, which forms the impounding reservoir, is about 250 acres in area. The bottom is formed of fine sand, but that is overlaid with silt. Now, the question comes to us, — Is it safe for us to take the silt off, or shall we leave the silt there to prevent underground leakage?

Mr. Horton: I should think that would depend somewhat on the history of the situation. If you knew whether you got a smaller yield from that reservoir in the days after it was first built and before that silt deposit had occurred, then that would afford a good basis for answering the question. My own experience has been that you are very likely to lose water by taking the silt insulation off from a stream bed or reservoir bottom if there is an opportunity to lose it. Of course, if there is no opportunity to lose it anyway, then you will not lose it. But I have known of several instances where the removal of the silt from the stream bed or reservoir bottom has had just that effect, — to permit the water to drain off for a time, until a new insulation was formed.

Mr. W. A. MacKenzie. In the case of a reservoir for a large private establishment some three years ago, they built a dam, and the owner was very anxious to have the basin of this reservoir cleaned out so that it would present a much nicer appearance for swimming pools, and so forth. So that we used a large amount of the basin material, which was a sort of clay and silt, at the bottom side of an earth dam. This dam had a concrete wall and proved to be very tight. There was a gully that was very near equal to the depth of our own pond, some 100 ft. to one side, where another stream flowed. We cleaned out this reservoir, and went up on the side of the banks considerably with the loam, clay, and silt. The water in the gully has more than doubled since the pond was filled, and up to the present time the bank has not silted up. I told the owner at the time that I thought perhaps this bank would silt up and the leakage would decrease, but up to the present time it has not. In this particular case it was not a water supply, and the leakage has not caused any damage. But it was of considerable concern to the owner, as in the dry weather there was not as much water running over the dam as there would have been otherwise. So I think that, perhaps, it is rather a risky proposition to

clean the entire basin if it is a water supply, and the material that is in the basin will not materially affect the character of the water.

MR. CHARLES W. SHERMAN. The experience of the last speaker brings to my mind rather an interesting experience I had a number of years ago, and reminds me of what I sometimes like to call the "cussedness of inanimate things." We all know that, if we build a filter out of sand, the first thing it does is to plug up. I had to build, a number of years ago, a little dam to form a pond to add to the architectural landscape appearance of a large estate, and the only substance available with which to build it was sand. We put in concrete to such a depth as was practical within reasonable limits of expense, and I assumed that the sand embankment, with the aid of that concrete, was near enough like a filter so that it could be counted on to plug up in a few years. But to the best of my knowledge and belief it has not plugged up very much yet.

DANGEROUS REDUCTION OF INSULATION RESISTANCE IN HIGH-PRESSURE FIRE-SERVICE MOTORS, DUE TO MOISTURE.

BY WM. W. BRUSH, DEPUTY CHIEF ENGINEER, BUREAU OF WATER SUPPLY, DEPARTMENT OF WATER SUPPLY, GAS AND ELECTRICITY, CITY OF NEW YORK.

[*Read by* C. W. SHERMAN.]

An investigation of the change in insulation resistance of the electric motors which drive the high-pressure fire-service pumps at the four stations in Manhattan and Brooklyn has shown some interesting and rather surprising results. The story will be briefly told of what has been observed, and of what has been planned to prevent in the future dangerous lowering of the insulation resistance, in the hope that the experience of others will be set forth, and that those who have a similar operating and maintenance problem will be helped in the solution thereof.

High-Pressure Fire-Service Motors. The more important commercial sections of New York City lying in the boroughs of Manhattan and Brooklyn are afforded exceptionally effective fire protection by the high-pressure water-supply system which is used only for the extinguishment of fires. In each borough there are two stations which have pumping equipment of similar design. In each Manhattan station there are six 6-stage centrifugal pumps having a capacity of 3 000 gal. per minute when delivering against a pressure of 300 lb. per square inch, while in Brooklyn the main station has five such pumps and the reserve station three pumps. The pumps are driven by 6 600 and 6 300 volt induction motors in Manhattan and Brooklyn, respectively, those in Manhattan having been built by the Allis-Chalmers Company, and the Brooklyn motors by the General Electric Company. Ten of the Manhattan motors were installed in 1908 and two in 1911. All of the Brooklyn motors were installed in 1907. One of the Manhattan stations is on South Street, facing

the East River, while the other is on Gansevoort Street, adjoining the North River docks. The main Brooklyn station is on Joralemon Street, near the East River, and the reserve station on St. Edwards Street, about one mile from the river front. The proximity of three of the stations to the water increases the humidity of the air in their vicinity. The Manhattan and the reserve Brooklyn stations have the operating floor at the street level, while the main Brooklyn station floor is about ten feet below the street level. In all the stations the provisions for ventilation are normal. In the main Brooklyn station the basement is damp, and there is usually more moisture in evidence here than at the other stations.

Normal Operating and Maintenance of Motors. In Manhattan a motor is started upon receipt of an alarm in the district covered by the station, and the necessary pressure maintained until notice is given by the fire department that no further supply is required. The number of times the service is required averages 550 per year for each station. In addition, every twenty-four hours each motor is started and run for about five minutes, when not otherwise put in service. This operation is mainly for the purpose of testing the condition of the motors and pumps, but also helps to dry out the motors. In Brooklyn, up to the introduction of the Catskill water, the proper station covering the district affected started a motor on each alarm, but during the past two years a motor is not started unless more than about 100-lb. pressure is called for. Under present operating conditions the two stations combined only operate on about 121 fires per year. The practice of running each motor once each day for about five minutes has also generally been followed in Brooklyn.

Failure of Insulation of Three Motors in the Main Brooklyn Station. On August 20, 1917, there was a fire in Brooklyn, and after the station had been in operation for about forty-eight minutes one of the motors burned out. A second motor was started and ran for forty-two minutes, when it burned out; and a third motor was started and ran for sixty-six minutes, when it also burned out. A fourth motor finished the run on this fire, which required it to be in operation for about forty-five minutes. An examination showed that the insulation of the stators had

failed, and that they would have to be rewound. This work was done by the General Electric Company at a total cost of $5 305, the greater part of the work being done at the station. The order to make the repairs was given in August, 1917, and the repairs were not completed until December, 1917. One of the three motors developed a short circuit in its rotor when it was being tested after repairs, and this damage required two months to effect the repairs, and cost $2 120.45. It seems probable that the failure was due partly to the natural deterioration of the insulation from age, combined with severe conditions due to infrequent operation and high moisture. To minimize the danger of a repetition of failure from this cause, orders were given to run each motor for not longer than thirty minutes, and then change over to a fresh motor. Tests made at this time on the remaining machines at the Joralemon Street station showed insulation resistances from 1 to 1.8 megohms cold. Insulation resistances, measured warm, after twenty hours' baking by direct current of approximately full load amperage, sent through the stator coils, measured 0.7 to 1.8 megohms. These same machines showed 4 to 6 megohms cold.

This baking process was continued for about one week, at the end of which time the resistance cold measured from eight to ten megohms. The resistance warm, however, would drop to slightly under two megohms. It may be remarked that the weather conditions for the month of August, 1917, were relatively favorable, the humidity being considerably below and the sunshine considerably above normal. These machines were baked and varnished in January, 1918, after which the resistance measured some 300 megohms. In the summer of 1918, however, some eight months after the machines were baked and varnished, the insulation resistance dropped to slightly under two megohms on days when the weather conditions were unfavorable. In the spring of 1919, the writer's attention was called to the tendency for this insulation resistance to fall, and tests were made to overcome this by the application of external heat to the windings.

Inquiry of the manufacturers showed that they considered a minimum of five megohms resistance as necessary for safety of

operation, although operating men of experience gave their opinion that two megohms would be sufficient.

During the nine days of rain in July, tests were made in Manhattan and Brooklyn, which showed a resistance as low as 0.4 megohm on some motors. It is evident that the motors absorbed moisture from the air in sufficient volume to lower the insulation resistance to a dangerous degree, and that the operation of a motor still further increases this reduction in resistance and endangers the continuance in service of a motor in case it is required for fire use. Such a condition manifestly could not be permitted to continue, and it therefore became necessary to promptly determine the steps to be taken to secure an effective remedy.

Measures Taken to prevent Reduction in Insulation Resistance. It is evident that it is necessary to expel the moisture present in the insulation, and then either maintain a dry air around the motors, or else expel moisture from the motors at such intervals as might be found necessary to maintain a safe resistance. As far as could be determined, during the period when the stations were artificially heated, the resistance was reasonably high, but there is not sufficient evidence to be conclusive on this point. It was decided to try various devices, such as covering each motor with a canvas housing, which could readily be removed by one man in case the motor was needed for service, and apply heat, using a small steam coil at the base of the motor frame. The canvas cover is to be made so that circulation of air through openings can be secured if desired, and it is believed that the canvas hood and steam coil will prove effective. Whether heat will be applied continuously or intermittently will be determined by experiment. A meggar outfit has been requisitioned for use mainly to test these motors, and in the future regular as well as special tests will be conducted.

Consideration was given to the use of unheated air, dried by means of a special electric fan or blower, and this method offers interesting possibilities which may later be tried out by tests, but for the present the drying of the air by heating seems to be the surest in its results.

The writer believes that there are enough electric motor instal-

lations in connection with water plants to make the subject of the lowering of insulation resistance by moisture of interest to a number of operating superintendents, and trusts that the experience of others will be set forth for the guidance of all.

PROCEEDINGS.

June Meeting.

Hull, Mass., June 25, 1919.

The June meeting of the New England Water Works Association was held at Pemberton Inn, Hull, on June 25, 1919.

The following members and guests were present:

Honorary Members.

F. E. Hall. R. J. Thomas. — 2.

Members.

F. S. Bailey.
F. A. Barbour.
J. F. Barrett.
T. J. Carmody
J. E. Conley.
J. H. Dillon.
J. M. Diven.
Frank Emerson.
G. E. Evans.
G. H. Finneran.
F. L. Fuller.
F. J. Gifford.
A. F. Hart.
D. A. Heffernan.
H. W. Horne.
W. F. Hunt.
D. D. Jackson.
Willard Kent.
J. A. Kienle.
S. E. Killam.
F. A. McInnes.
Hugh McLean.
H. V. Macksey.
J. H. Mendell.
G. F. Merrill.
Leonard Metcalf.
H. A. Miller.
F. L. Northrop.
H. E. Perry.
G. A. Sampson.
G. G. Shedd.
J. F. Sullivan.
H. A. Symonds.
J. A. Tilden.
S. E. Tinkham.
E. J. Titcomb.
J. H. Walsh. — 37.

Associates.

Bond, Harold L., Co., by H. C. Bond.
Byers, A. M. Co., by H. F. Fiske.
Donaldson Iron Co., by C. F. Glavin.
Eddy Valve Co., by H. R. Prescott.
Edson Mfg. Co., by H. L. B. Watson.
Engineering and Contracting, by R. E. Brown.
Engineering News-Record, by I. S. Holbrook.
Gamon Meter Co., by R. J. Thomas.
Hersey Mfg. Co., by W. A. Hersey, J. H. Smith.
Pittsburgh Meter Co., by G. C. Northrop.
Rensselaer Valve Co., by I. A. Rowe, C. L. Brown.
Smith, A. P. Mfg. Co., by F. L. Northrop.
Thompson Meter Co., by E. M. Shedd.
Union Water Meter Co., by H. L. Jacobs.
United Brass Mfg. Co., by G. A. Caldwell.

Ludlow Valve Mfg. Co., by A. R. Taylor.
Mueller, H., Mfg. Co., by C. J. G. Haas.
National Meter Co., by J. G. Lufkin, H. L. Weston.
Pitometer Co., by E. E. Case.
United States Cast Iron Pipe & Foundry Co., by W. P. Mosteller.
Water Works Equipment Co., by W. H. Van Winkle.
Wood, R. D., & Co., by R. M. Simon.
Worthington Pump & Machinery Co., by Samuel Harrison. — 26.

GUESTS.

MASSACHUSETTS.

Boston, Carl S. Ell, Mary E. Evans, Carroll A. Farwell, Arthur L. Gammage, Miss Joan M. Ham, E. R. Simpson, Samuel E. Stott, Mrs. J. A. Tilden, Lester W. Tilden, Mrs. S. E. Tinkham.
Cambridge, Eugene F. Sullivan.
Canton, Charles N. Reynolds.
Chicopee, Peter C. Garrity.
Cliftondale, Mrs. A. F. Hart.
Dedham, Allan T. Gifford.
Greenfield, Major Elwin S. Warner.
Holyoke, Mrs. T. J. Carmody, Mrs. J. H. Dillon, Miss Helen Hanley, Miss G. Sullivan, Miss Marion McLean.
Lynn, Mr. and Mrs. F. G. Berry, Dorothy B. Carpenter.
Needham, Mr. and Mrs. C. S. Bryer.
Norwood, Carl B. Reed.
Peabody, Joseph A. Ryan.
Somerville, James E. Stone.
Waban, David Sutton.
Waltham, Frank L. Preble.
Watertown, John N. Cashman.
Wellesley, Francis P. Hersey, Winthrop P. Hersey.
Winchester, H. W. Dotten.
Winthrop, Mr. and Mrs. O. D. Rice.
Woburn, Hon. W. E. Blodgett.
Wollaston, Edwin F. Allbright, Mrs. J. H. Smith, Ellsworth Smith.

RHODE ISLAND.

Bristol, J. M. Jones.
Narragansett Pier, Mrs. Willard Kent.

NEW YORK.

New York City, C. B. Hayward, Mrs. W. H. Van Winkle.

NEW JERSEY.

Elizabeth, Mr. and Mrs. C. N. Bingham. — 47.

The Secretary presented applications for membership, properly endorsed by the Executive Committee.

The Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared elected.

Hon. W. E. Blodgett, ex-mayor of Woburn, Mass., gave a very interesting talk on the welfare work among our boys at the rest camps in France.

Adjourned.

WILLARD KENT, *Secretary.*

THIRTY-EIGHTH ANNUAL CONVENTION.

ALBANY, N. Y.,

September 30, October 1, 2, 3, 1919.

The thirty-eighth annual convention of the New England Water Works Association was held at Albany, N. Y., September 30, October 1, 2, and 3, 1919.

The sessions of the convention were held at the Hotel Ten Eyck, where also were provided accommodations for the exhibits of Associates.

The following members and guests were present:

HONORARY MEMBERS.

Rudolph Hering. G. A. Stacy. R. J. Thomas. — 3.

MEMBERS.

G. H. Abbott.	A. N. Burnie.	R. L. Dobbin.
D. L. Agnew.	J. M. Caird.	J. S. Dunwoody.
S. A. Agnew.	T. J. Carmody.	E. D. Eldredge.
M. N. Baker.	A. M. Chaffee.	R. H. Ellis.
L. M. Bancroft.	C. E. Chandler.	Frank Emerson.
F. A. Barbour.	A. T. Clark.	A. B. Farnham.
W. T. Barnes.	E. S. Cole.	S. F. Ferguson.
G. W. Batchelder.	William Colquhoun.	G. H. Finneran.
G. H. Bean.	W. R. Conard.	M. E. FitzGerald.
F. E. Beck.	H. R. Cooper.	A. P. Folwell.
James Bedell.	G. K. Crandall.	B. E. Fox.
G. A. Benjamin.	H. C. Crowell.	E. V. French.
F. D. Berry.	John Cullen.	F. L. Fuller.
A. E. Blackmer.	F. A. Darling.	F. C. Gamwell.
George Bowers.	D. A. Decrow,	Patrick Gear.
Bertram Brewer.	J. H. Dillon.	H. T. Gidley.
H. A. Burnham.	J. M. Diven.	F. J. Gifford.

T. C. Gleason.
H. J. Goodale.
F. W. Gow.
F. W. Green.
D. R. Gwinn.
L. M. Hastings.
W. C. Hawley.
C. B. Hayward.
D. A. Heffernan.
R. E. Horton.
A. C. Howes.
W. F. Hunt.
G. A. Johnson.
J. M. Jones.
J. W. Kay.
F. T. Kemble.
T. R. Kendall.
Willard Kent.
S. E. Killam.
G. A. King.
H. C. Kinney.
John Knickerbacker.
Morris Knowles.
Paul Lanham.
T. F. Lawlor.
M. B. Litch.
B. C. Little.
F. F. Longley.
F. H. Luce.
P. J. Lucey.
S. H. MacKenzie.
W. A. McKenzie.
D. B. McCarthy.
J. R. McClintock.
H. S. R. McCurdy.
J. A. McKone.
E. T. McDowell.
Hugh McLean.
W. H. McMahon.
H. V. Macksey.
A. E. Marton.
W. P. Mason.
H. P. T. Matte.
E. E. Miller.
M. L. Miller.
J. W. Moran.
F. A. Nagler.
E. B. Norton.
J. A. Newlands.
W. H. O'Brien.
W. J. Orchard.
Alexander Orr.
C. E. Peirce.
A. E. Pickup.
J. F. Reagan, Jr.
J. H. Remick.
J. L. Rice.
R. M. Roper.
G. A. Sampson.
H. W. Sanderson.
C. M. Saville.
F. W. Schwartz.
W. P. Schwabe.
C. W. Sherman.
R. W. Sherman.
J. Waldo Smith.
G. H. Snell.
S. B. Story.
J. F. Sullivan.
W. F. Sullivan.
Russell Suter.
S. A. Sweell.
E. A. Taylor.
S. H. Taylor.
J. A. Tilden.
A. H. Tillson.
D. N. Tower.
Louis Trial.
W. J. Turnbull.
Lincoln Van Gilder.
L. M. Wachter.
I. S. Walker.
J. H. Walsh.
H. T. Wheelock.
J. F. Whitney.
I. S. Wood.
C. L. Wooding.
L. C. Wright. — 139.

ASSOCIATES.

American City, The, by L. P. Anderson.
Builders' Iron Foundry, by J. D. Purdue, G. H. Lewis, A. B. Coulters, and F. N. Connet.
Byers, A. M. Co., by C. F. Uhler, H. F. Fiske, and J. J. Riley.
Carbic Mfg. Co., by E. G. Frey.
Central Foundry Co., by R. W. Conrow and Stuart Root.
Dixon Crucible Co., by L. M. Chase.
Badger Meter Mfg. Co., by W. S. Cetti.
Eddy Valve Co., by H. A. Holmes and F. S. Robinson.
Electro Bleaching Gas Co., by J. A. Kienle and S. W. Jacob.
Engineering and Contracting, by R. E. Brown.
Engineering News-Record, by H. M. French, Wm. Buxman, Wm. Van Kluck, I. S. Holbrook, and R. K. Tomlin.
Fire and Water Engineering, by K. M. Mann, R. H. Lockwood, and W. J. Berger.

Ford Meter Box Co., by E. H. Ford.
Gamon Meter Co., by R. J. Thomas.
Hays Mfg. Co., by F. F. Myers and A. R. Johnson.
Hersey Mfg. Co., by J. H. Smith and W. C. Sherwood.
Leadite Co., The, by George McKay, Jr.
Lead Lined Iron Pipe Co., by T. E. Dwyer.
Lock Joint Pipe Co., by H. E. Pride.
Ludlow Valve Mfg. Co., by A. R. Taylor, J. H. Caldwell, and Harold Burgess.
Mueller Mfg. Co., by C. J. G. Haas and James Mashell.
Municipal Journal and Public Works, by S. N. Hume.
National Meter Co., by J. G. Lufkin and H. L. Weston.
National Tube Co., by H. T. Miller.
National Water Main Cleaning Co., by B. B. Hodgman.
Neptune Meter Co., by T. D. Faulks, W. H. McGarry, Jr., Chas. Bachmann, and J. R. Van Gorder.
N. Y. Continental Jewell Filtration Co., by A. W. Crane and A. L. Solleder.
Norwood Engineering Co., by H. N. Hosford.
Pitometer Co., The., by E. D. Case.
Pittsburgh Meter Co., by G. C. Northrop, V. E. Arnold, J. W. Turner, and J. J. Salmond.
Rensselaer Valve Co., by I. A. Rowe and C. L. Brown.
Ross Valve Mfg. Co., by William Ross.
Smith, A. P. Mfg. Co., by D. F. O'Brien, A. C. Nieman, T. F. Halpin, and F. L. Northrop.
Taylor, W. P. Co., by P. J. Weigel.
Thomson Meter Co., by H. F. Hoyt, J. L. Atwell, E. M. Shedd, and F. M. Watson.
S. E. T. Valve and Hydrant Co., by C. L. Lincoln.
Union Water Meter Co., by D. K. Otis, E. W. Jacobs, and H. W. Jacobs.
United Brass Mfg. Co., by G. A. Caldwell, W. N. Fairfield, and H. M. Flemming.
United States Cast Iron Pipe and Foundry Co., by W. P. Mosteller.
Wallace & Tiernan Co., Inc., by M. F. Tiernan, R. V. Donnelly, and A. Johnstone.
Water Works Equipment Co., by W. H. Van Winkle.
R. D. Wood & Co., by C. R. Wood and R. M. Simon.
Worthington Pump and Machinery Corp., by Samuel Harrison and C. C. Brewster. — 85.

Guests.

Maine.

Auburn, Mr. and Mrs. A. W. Cobb.
Castine, Mrs. G. A. Benjamin.
Freeport, Mrs. D. E. Roelick.

New Hampshire.

Claremont, Mrs. J. L. Rice.
Derry, George G. Bean.
Nashua, Frank B. Clancy.
Tilton, Mrs. E. Hill, Mrs. C. J. Morse, and Mrs. C. Varnum.

MASSACHUSETTS.

Boston, Mrs. W. T. Barnes, Master Wellington T. Barnes, Miss Joan M. Ham, Mrs. S. E. Killam, Mr. and Mrs. R. M. Kinsman, C. B. Moore, Mrs. J. A. Tilden, Lester W. Tilden, and A. M. Thomson.
Cambridge, Mrs. L. M. Hastings.
Chelmsford, Mrs. W. H. McMahon.
Chicopee, Edward C. Frazier, Peter C. Garrity, and James J. Page.
Cohasset, Mrs. D. N. Tower and Miss B. L. Tower.
Dedham, Mrs. F. J. Gifford, Allan T. Gifford, Mrs. T. Piercy, and Harry R. Wragg.
Fall River, James J. Kirby and A. J. Brunette.
Franklin, Henry J. Cockell.
Haverhill, Mrs. H. C. Crowell.
Holyoke, Leo W. Beacon, Mr. and Mrs. Wm. Brick, Mrs. T. J. Carmody, Mrs. J. H. Dillon, and Elsie McLean.
Littleton, Mrs. J. H. Remick.
Lowell, Alton R. Bowers, Mrs. W. F. Hunt, Mr. and Mrs. George Marchand, Charles J. Morse, and Mrs. R. J. Thomas.
Malden, Fred M. Prescott.
Marlboro, Mrs. G. A. Stacy.
Medford, Mrs. F. W. Gow.
Milford, Mrs. J. W. Kay and Miss I. T. Nelson.
Milton, Mrs. D. A. Heffernan.
Oxford, Mrs. A. M. Chaffee, Lester J. Chaffee, Sarah Chaffee, and Hazel G. Foster.
Palmer, Mrs. F. C. Gamwell.
Peabody, Mrs. Frank Emerson.
Pittsfield, Mrs. A. B. Farnham and Frank Martineau.
Plymouth, Mrs. A. E. Blackmer.
Southbridge, Mrs. G. H. Abbott.
Southampton, Mrs. C. D. Powers.
Springfield, Charles W. Winslow.
Waltham, Mrs. Bertram Brewer and Mrs. E. A. Moulton.
Ware, Mrs. J. E. Gleason.
Westfield, Alfred O. Sanford.
West Springfield, I. T. Alstrom, Mr. and Mrs. G. N. Norris, and Mrs. J. F. Whitney.
Winthrop, Harry A. Ford.
Woburn, Mrs. H. V. Macksey.

RHODE ISLAND.

Narragansett Pier, Mrs. Willard Kent.
Providence, Mrs. I. S. Wood.
Woonsocket, Miss Catherine Mullaney.

CONNECTICUT.

Bristol, Mrs. C. L. Wooding and Helen Wooding.
East Hartford, Mrs. J. H. Walsh.
Hartford, Mr. and Mrs. S. H. Berry, John Carlson, J. T. Carmody, Martin Cannon, J. J. Donneley, J. J. Dennehy, E. L. King, E. D. Magens, Arthur J. McManen, Mrs. C. M. Saville, D. F. Sullivan, Humphrey Sullivan.
New London, Mrs. G. K. Crandall.
Norwich, Mrs. C. E. Chandler.
Southington, Mrs. S. H. MacKenzie, Miss Eunice MacKenzie, Miss Fannie MacKenzie, and Daniel F. Shanahan.
Unionville, Charles A. Hackney.
Wallingford, Mrs. W. A. MacKenzie.

NEW YORK.

Albany, Louise Anderson, J. H. Brewster, E. S. Chace, Mrs. Wallace Greenalch, Mrs. Theodore Horton, Alex R. McKim, Frank B. Northrop, G. B. Nichols, Miss E. H. Sherman, and James Wyllie.
Buffalo, Mrs. P. J. Weigel.
Cambridge, Mrs. Eliot B. Norton.
Cohoes, Edward Hayes.
Glens Falls, G. M. Doughy.
Mamaroneck, Mrs. R. E. Brown.
New York, Homer N. Calver, Harry Gardner, Mrs. C. L. Lincoln, Mrs. D. B. McCarthy, E. G. Reynolds, Jr., Franklin Van Winkle, and Mrs. Walter Van Winkle.
Poughkeepsie, Elbert W. Sylverter.
Rensselaer, Mr. and Mrs. C. R. Claflin.
Stapleton, W. Volkhardt.
Troy, Mrs. F. S. Bates, James A. Beatie, Mrs. Fred Bowen, Hon. C. F. Burns, Mrs. James M. Caird, Mr. and Mrs. C. E. Clixton, H. M. Dibert, Miss C. S. Edgley, Mrs. W. C. Feathers, Mrs. E. F. Peakes, Palmer C. Ricketts, A. E. Roche, Mrs. I. A. Rowe, M. W. Shaughnesy, and Mrs. J. B. Wilbur.
Wappingers Falls, F. J. Bain.
Watervliet, Mr. and Mrs. C. S. Keating.
Yonkers, Mrs. Wm. Colquhoun and Mr. and Mrs. Thomas H. See.

NEW JERSEY.

Atlantic City, Mrs. Lincoln Van Gilder.
Asbury Park, Mr. and Mrs. C. H. White and Miss Geraldine White.
Little Falls, Mrs. F. W. Green.
Maplewood, Mrs. W. J. Orchard.
Madison, Herbert K. Saxe.
East Orange, Mrs. R. M. Roper.

PENNSYLVANIA.

Philadelphia, E. M. Nichols and Mrs. C. R. Wood.
Scranton, W. A. Wilcox.

MARYLAND.

Lanham, Mrs. Paul Lanham, Paul T. Lanham, and Helen Wood.

WEST VIRGINIA.

Morgantown, G. H. Bayles.

ILLINOIS.

Mattoon, G. W. Bailey.

CANADA.

Toronto, Mr. and Mrs. N. J. Howard.
— 169.

Morning Session, Tuesday, September 30, 1919.

The convention was called to order at 10 A.M. by Mr. Russell Suter, chairman of the Committee on Local Members. In opening the convention Mr. Suter spoke as follows:

Mr. Suter. Before proceeding with the regular business of the convention the Association will be welcomed to Albany. The city which welcomes us has been so democratic as to elect this year as its mayor an engineer and contractor. I take great pleasure in presenting to you the Hon. James R. Watt, mayor of Albany. [*Applause.*]

Address of Welcome by Hon. James R. Watt.

Mr. Chairman, Ladies, and Gentlemen, — It is indeed a pleasure to be here this morning to welcome you delegates to the little old city of Albany. I say " old " city, because it is the second oldest incorporated city in the United States. We are very proud of Albany; we are very proud to call this a convention city. During the past year and a half under my administration and the new Chamber of Commerce, both working together, we have striven to make it a convention city, and we have been successful. We therefore appreciate all the conventions that can be brought here, and gladly welcome each and every one of you to the city. While you are here we want you to feel free and easy to take in all the sights. We have many historical sights here. And to the ladies particularly I would suggest that if possible they take in the Educational Building, which will entertain them easily for a whole day, if they can spare that time.

The chairman has said that I am an engineer and contractor. I should like to correct that by saying that I am a contractor and half an engineer. But I appreciate the troubles engineers have, and I also appreciate, and no doubt you do, that the work which you have before you now — principally water — is an all-absorbing topic at the present time; has been since July 1. [*Laughter.*] And it probably will continue to be for some time to come. Water, of course, has been considered a food product; now it will be a food and beverage.

Do not hesitate on our water. We are proud of our water system. We have, we think, as fine a water system as there is in the country. I understand that you are going to inspect the system, and I hope that you will agree with us on the conclusion of that trip that our judgment is correct. We feel that our water here is a little better than Ivory soap, which is advertised as 99.44. Our chemists say our water is 99.90.

Now, seriously, we do welcome you, each and every one of you, to the city, and I sincerely hope that your visit here will be one of pleasure and profit, not only to yourselves but to the city of Albany. I thank you. [*Applause.*]

Mr. Suter. Not only are we the guests of the city of Albany, but many courtesies have been shown to us by the Chamber of Commerce. The Chamber of Commerce will welcome us, represented by the secretary-manager, Mr. Roy S. Smith. [*Applause.*]

Address of Welcome by Mr. Roy S. Smith.

Mr. Chairman, Ladies, and Gentlemen, — The Mayor has presented to you the formal and official welcome from the city; I desire to extend to you, in coöperating with him and supporting him, the official welcome of the civic organization, the Albany Chamber of Commerce. The Mayor could have spoken as well for the Chamber of Commerce, because it so happens that he is a member of the board of directors of the Albany Chamber of Commerce, and so while I am on behalf of the board of directors speaking to you, I am also coöperating with one of my bosses who is a member of the board.

It is true that the Chamber of Commerce and the City Administration have worked in perfect harmony for the development of this magnificent community. And on behalf of our organization — which I am very pleased to say to those ladies who are present numbers nearly one hundred women members — we extend to each and every one of you a very cordial welcome to this city, of which we are so proud. If any of you like it so well while you are here that you desire to change your addresses, you will find our offices down in the corner of this building, where we will be very glad to make arrangements to permanently locate you here. While

we know that you are all loyal citizens of your communities, yet we desire while you are here to make you feel perfectly at home in Albany.

It will interest you to know that the first steam railroad train which operated in the world started its trip from this city. The first long-distance aëroplane trip in the world started from Albany to New York City, when Glenn Curtiss made the famous ride down the Hudson River. And at the present time the Albany Chamber of Commerce, working with the City Administration, has established the first aëroplane landing field in the United States. It was here that the first electric spark was invented which ultimately made possible the telegraph and the electric motor. And here we have a community which we are very proud to say contains one hundred per cent. Americans.

Albany, as the Mayor said, is the second oldest incorporated city in the United States, having been incorporated in 1686. It is the third largest mail transfer point in the United States; it is the second largest express transfer point in the United States, excelling both New York and Philadelphia in those two particular points. There are so many things for you to see here that it is difficult for me, as a member of the Chamber of Commerce, to see how you are going to see them all; but I want you to do your best.

I feel you are just a little in the position of a colored soldier friend of mine who was in camp down on Long Island. He had served his first week out, and it came Saturday night, and time for him, as he supposed, at the end of a week, to go home. Concluding his week's work with Uncle Sam he laid down his rifle and started to go home. Arriving at the gate he was challenged by the sentry, who said, "You can't go out here." "Why not? my week's work am done." "You haven't any pass; you can't go by here"; and he pointed his bayonet at the soldier. The colored soldier reached down and pulled out a razor, which he commenced to strop on his boot-leg, saying, "I have a mother in heaven, a father in hell, and a girl in Harlem; I am going to see one of them three to-night." [*Laughter.*]

Now, there are a great many things of interest for you to see in Albany, and while I know it will be impossible for you to see them all, I ask you to go as far as you can and consider the city is yours.

The offices of the Chamber of Commerce are on the ground floor of the Ten Eyck Hotel. Everything that we have there, including writing materials, will be at your disposal. The more the members of your convention take advantage of the Chamber of Commerce, the more pleased we will be.

I understand there has been arranged an entertainment program for you. I am authorized by Mr. Winchester, president of the Woolferts Roost Country Club, to invite each and every one of you to make use of the privileges of the club, which are at your disposal while you are in the city.

If any of you get in trouble, the Mayor will be at the telephone at his office and will see to it that you get out of that trouble.

Seriously, we are very glad you are here. Our entire facilities are at your disposal, and I should like you to appreciate that this city is noted for its wealth of hospitality and the warmth of its greeting. [*Applause.*]

Response by President Samuel E. Killam.

Mr. Mayor and Gentlemen of Albany, — The warmth of your reception has deeply impressed me. We anticipated a generous welcome at your hands, for the fame of your hospitality has been generally known among our members.

Although this is our first visit to Albany as an Association, we have heard of your city historically, commercially, politically, and socially, and know that your city keeps abreast of the improvements and demands of the age.

We fully appreciate the genuine heartiness of your welcome and the excellent rooms that have been provided for our meeting, and we know that under your guidance we shall greatly enjoy our stay in your beautiful city.

Gentlemen of the city of Albany, in the name of the New England Water Works Association, it gives me the greatest pleasure to thank you again for your kind words and cordial greetings.

Address by President Samuel E. Killam.

Fellow-Members of the New England Water Works Association and Guests, — The thirty-eighth annual convention of the New England Water Works Association meets to-day in this beautiful

city of Albany, where the first league of the colonies was proposed by Benjamin Franklin in 1754. This plan was rejected by the British crown because it gave too much power to the colonies, and by the colonies because it gave too much power to the crown. The significance of this congress lies in the fact that it stimulated the union of the colonies which afterwards became a reality.

I do not propose to dwell unduly upon the problems that confront us in this reconstruction period, which is now in the making after the close of the greatest war in the history of the world. The war is over, although the treaty of peace has not been ratified. Let us hope that whatever the final agreement may be it will prove as beneficial to the United States as resulted from the rejection of the league of the colonies by both parties in 1754.

We are passing through a period of unrest. The whole social structure of governments has been shaken and our own democratic government has not entirely escaped. Our own Association has felt this unrest perhaps no more than other similar organizations, but the cause of this must be found and mastered. We are water-works men, and meet primarily to consider matters pertaining to water supplies; but are we meeting the individual needs of our members?

Our founders — who builded better than they knew — may well look back with pride on the work that has been accomplished, but do the original aims satisfactorily meet our individual needs of to-day?

In this serious period let us not forget that the Association is in our hands, to be molded as we choose. Is it not well to cultivate our neighbors and enter upon all problems with open minds and in the spirit of coöperation? A careful consideration of our own particular needs will cause to increase our security in water-works fraternity.

If we are to continue to grow we must meet the individual needs of the practical water-works man. We must stand behind every superintendent in his endeavor to fulfill his office in an honest, capable, and efficient manner. The individual must feel that the strength of the Association is behind him to aid him in every honest effort that he may make to better the community that he serves.

There are many problems that the modern water-works executive must meet. Among them is the introduction into the state legislatures of bills that, if enacted, would become a serious menace to public health. Individual efforts in such matters are not adequate. It is necessary for members to get together and, with the cooperation of similar organizations, see to it that the members of the legislature realize the heavy personal responsibility which rests upon them in passing measures that would lower the standards and jeopardize the public health for the pleasure of the few. I believe that it would be well to have a committee in all of the thirty-seven states in which we have members to watch for the introduction of such bills in state legislatures and report to the Executive Committee of the Association in order that this Association may be on record as against any legislation that tends to lower the standards and injure the public health of the state.

Our permanent headquarters have been of great benefit to the Association, but I believe that the force should be reorganized so that it will be of practical use to individual members, and thus make the New England Water Works Association a strong, influential body. The office at headquarters should be the source of all water-works information. Such, however, cannot be fully realized without a sufficiently paid local secretary. Our resources at the present time are such, however, as not to permit of the reorganization of the office force on this basis. I think that you will all agree with me when I say that some executive officers should be in personal touch with headquarters, In making this suggestion no reflection is cast upon our faithful Secretary, who, on account of his home location, finds it impossible to give his personal attention to headquarters. If the present organization is to continue, I suggest that the office of assistant secretary be created in order that a member may be in touch with work at headquarters, assist in research work of committees, and that all matters pertaining to the Association be suitably filed and indexed. In this way I believe that a foundation could be built which would be immovable.

The budget system, which on the whole has worked very well, is now being adopted by states, municipalities, private concerns, and even organizations similar to our Association. Detailed estimates of sums required for various expenditures are made

previous to the beginning of the fiscal year. I believe that it is advisable for this Association to make a study of its finances in view of putting such a system into practice in 1920. I would recommend that our Finance Committee, or a special committee, take up this problem and report their findings to the Association not later than our December meeting.

I also recommend that a committee be appointed to make a study of our constitution and by-laws, to ascertain if there are any changes or additions that it seems desirable to make before the publication of the 1920 year-book.

I believe that it is necessary for us to expand if we are to maintain our place among the technical societies of our country. There has been no serious loss in membership; neither has the membership increased as rapidly as is desirable. How can we grow in numbers and still be healthy? I know of only one way, and that is to arouse the individual to the sense of the responsibility that rests upon him to extend the good influences of the Association.

I believe that the New England Water Works Association will take the initiative and maintain its enviable record of usefulness through its excellent work of special committees. It is desirable to coöperate with similar organizations in order to produce fewer conflicting standards. Next in importance to coöperation of committees between societies are conferences between committees and manufacturers on specifications for supplies used in water-works construction. The presence of a representative of the manufacturers at such committee hearings is an indication that we are broadminded enough to look beyond our own border and consider the general progress of established industries.

To-day we meet in convention. Let us be punctual in attendance upon the meetings, and may earnestness of purpose characterize the sessions.

We welcome those who have been in the service of our country during the past months, and extend to them our heartfelt esteem for the manner in which they have performed their valuable service when the country was sorely in need of trained men.

We welcome the families and friends of our members to this convention. May they find pleasure in attending our sessions as well as the excellent entertainments provided for them.

I wish particularly to thank the various convention committees for their able and painstaking work, and the Water Works Manufacturers Association for their generous support of the convention.

We are indebted to many, and to all we return thanks.

In conclusion I wish to say that what we need primarily is individual service for the practical water-works operators in order that we may grow and develop as an association. Let us enter upon our work in the spirit of coöperation for higher ideals, better service, and the best interests of the New England Water Works Association. [*Applause.*]

Mr. Thomas J. Carmody. If I may be permitted to say it, I think we ought to pass a vote of thanks for the document just read by our President.

I would move, if in order, that a vote of thanks be extended to our presiding officer for the very able paper which he has read, giving an outline of the work of this Association for the past year.

(The motion was duly seconded, and the question was put by Secretary Kent and carried unanimously.)

Award of Dexter Brackett Medal.

President Killam in the chair.

President Killam. The first thing on our program is the presentation of the Dexter Brackett Memorial Medal. I will ask Mr. Barnes, chairman of the committee, to step forward, and also Mr. David A. Heffernan.

Mr. William T. Barnes. *Mr. President, Members of the Association, and Friends,* — It was about twenty-five years ago that I first had the pleasure of attending a New England Water Works convention, in Boston. Of the members present at that time,— aside from our revered friend, Mr. Coggeshall, whom I had known before, — the one person whom I remember more particularly than any one else was Dexter Brackett.

Dexter Brackett at that time was comparatively young, and he showed a keen interest in this Association by giving it his individual support in the work of important committees and by presentation of papers.

It is fitting that his friends and associates should have established

as a memorial to Dexter Brackett the award of a medal to be known as " The Dexter Brackett Memorial Medal," to be awarded each year for the most meritorious paper delivered during the preceding year. It falls to me, as chairman of the Committee on Awards, to make the announcement of this award for the most meritorious paper during the year 1918.

It was not an easy task for the members of that committee to decide this question, but I am glad to say that by a unanimous vote it was decided that Mr. David A. Heffernan, superintendent of water works at Milton, in the delivery of his paper entitled, " Practical Methods for Detecting Leaks in Underground Pipes," was entitled to the medal for the year 1918. [*Applause.*]

It is needless for me to say more, Mr. Heffernan, in presenting this medal to you. The paper speaks for itself. It gives me great pleasure, therefore, to make this award. [Handing medal to Mr. Heffernan.] [*Applause.*]

Mr. David A. Heffernan. *Mr. President and Members,* — Really, I am surprised. I do not know what to say; I never expected anything like this. But I want to thank the Association, also the committee, for their generous gift. I think that every superintendent interested in water works should try to keep up the best interests of the Association, bringing forth papers, and so forth, so as to keep the work of the Association up to standard. I will say that I shall try always to work for anything that comes up that will be any improvement, and if there is anything that I can do to be of assistance I shall be glad to do it. I thank you.

Mr. Patrick Gear. In regard to the awarding of this medal to Mr. Heffernan, I hope that the superintendents all over New England will realize that they have a chance to get this medal themselves at some future time. When the giving of a medal was first proposed we all thought that nobody would ever get the medal but an engineer. I am glad to say that this has not been the case. An engineer got the first one, a water adjuster got the second one, and a practical superintendent has now gotten the third one. So that we are now even with the engineers, and it is up to the superintendents to see if they can't beat them right along.

President Killam. I might say that without doubt this is a genuine surprise to Mr. Heffernan. The award was made by the

Executive Committee recently, who saw fit not to tell Mr. Heffernan until they got him here on the floor.

The Secretary read the following names of applicants for membership, all of whom had been approved by the Executive Committee, and they were duly elected:

Active: Charles R. Barker, Boston, Mass., engineer, New England Insurance Exchange; Samuel A. Sewell, St. John, N. B., superintendent, Water and Sewerage Department; John S. Caldwell, Boston, fire protection engineer; John A. McKone, Hartford, Conn., president Board of Fire Commissioners; Francis W. Collins, New York City, consulting engineer; Francis J. Seery, Ithaca, N. Y., hydraulic engineer, U. S. Geological Survey; Francis C. Millspaugh, Lowell, Mass., hydraulic engineer; Irving H. Henderson, Cambridge, Mass., foreman Meter Department, Cambridge Water Works; Jno. F. Laboon, Pittsburgh, Pa., civil engineer; Eliot B. Norton, Cambridge, N. Y., superintendent water works. — 10.

Associate: Flower Valve Manufacturing Co., Detroit, Mich., manufacturers hydrants, valves, etc.; *Engineering and Contracting*, Chicago, Ill.; *Municipal Journal and Public Works*, New York City; New York Continental Jewel Filtration Company, Nutley, N. J., manufacturers of gravity and pressure filters. — 4.

Roosevelt Memorial Resolution.

The Secretary then read a communication from the Roosevelt Memorial Association, suggesting the adoption by the New England Water Works Association of the following resolution:

" *Whereas*, the Roosevelt Memorial Association has been formed by the friends of the late Col. Theodore Roosevelt to honor his memory; and

" *Whereas*, the Roosevelt Memorial Association aims to provide memorials in accordance with the plans of the National Committee which will include the erection of a suitable and adequate monumental memorial in Washington; and acquiring, development, and maintenance of a park in the town of Oyster Bay which may ultimately, perhaps, include Sagamore Hill, to be preserved like Mount Vernon and Mr. Lincoln's home at Springfield; and

" *Whereas*, the Roosevelt Memorial Association announces a national campaign for funds in the week of October 20–27; and

" *Whereas*, the sum of five million dollars is to be raised through the subscription of millions of individuals;

" Therefore, be it

" *Resolved*, that..... recognizing his superlative Americanism and his inestimable services to our

nation as citizen and statesman, hereby records its hearty endorsement of the plans of the Roosevelt Memorial Association and pledges its support to the national campaign to be conducted by that Association."

MR. FRANK L. FULLER. I move, Mr. President, that the resolution be adopted.

(The motion was seconded.)

MR. H. V. MACKSEY considered the resolution somewhat indefinite, and called attention to the obligation of the Association if a formal endorsement were given. He also spoke of the limited means of the Association, the numerous calls for financial response for numerous worthy public purposes, and counseled that further consideration be given before the Association committed itself in this manner.

Mr. Macksey favored individual subscriptions rather than an Association subscription.

MR. RICHARD W. SHERMAN concurred in the views of Mr. Macksey, and while expressing the greatest admiration for Colonel Roosevelt, and referred to statements that he was the greatest man America ever produced, favored individual subscriptions, and questioned if the Association should properly make a contribution for a purpose of this kind.

MR. HUGH MCLEAN called attention to the numerous demands for funds for worthy causes, and while he personally wished to give his strongest support to any proper measure in honor of the late President Roosevelt, he did not favor a direct contribution by the Association.

Mr. McLean advised receiving the resolutions and placing them on file, and doing our best individually to contribute to this fund.

MR. FULLER spoke in favor of his motion, and stated that he believed a reasonable contribution would be better than individual subscriptions.

MR. MACKSEY. Mr. President, if I may be allowed by the maker of the motion, I would like to substitute therefor a motion to this effect:

"The New England Water Works Association approves the effort that is being made by the Roosevelt Memorial Associa-

tion, and is in full sympathy with it, and heartily recommends to its membership, one and all, to contribute to the success thereof, as far as their means will allow."

(The substitute motion was seconded.)

MR. MCLEAN. I should like to make a motion that the communication be received and laid on the table. I will give you my reasons for it. Only a few days ago this matter was introduced in a similar organization to which I belong, and the question came up some time after its adoption as to whether or not we had the right to take from our treasury twenty-five dollars for this, twenty-five dollars for that, and twenty-five dollars for something else, and we finally had quite a debate and discussion. We better take those things into consideration in advance.

(The motion was seconded.)

MR. FRANCIS H. LUCE stated that he believed the resolutions were taken in the wrong light by the Association, and that no contribution was expected, but merely the moral support of the Association of the Memorial Committee and its work as outlined.

MR. CARMODY believed that the Association was on dangerous ground in doing more than receiving the communication and placing it on file. He spoke of the possible political influence, and compared the action of other organizations that simply received and placed on file the resolutions.

MR. RICHARD W. SHERMAN. In view of all that has been said, I move that the communication be received, placed on file, and laid on the table, that we acknowledge receipt of the communication and by laying it on the table it can be taken up at any time for such disposition as the Association may see fit. I take it that the members do not care to act hastily, and at the present time we do not seem to have time for any prolonged discussion. If it is laid on the table we can take it up at any time.

MR. MCLEAN. I accept that amendment.

PRESIDENT KILLAM. I understand you make that amendment to the original motion?

MR. SHERMAN. I do.

MR. MCLEAN. I made a subsequent amendment, which I think was seconded, and I understood it was before the body for debate and action.

MR. LUCE spoke in favor of action for or against endorsement and opposed laying the communication on the table.

(The question came upon the motion that the communication be received and laid upon the table, which was carried.)

PRESIDENT KILLAM. Is there anything further to bring before the Association before we start on the reports of committees?

MR. R. J. THOMAS. Mr. President, I move that the Chair be authorized to appoint a nominating committee of five members to bring in a list of candidates for the officers of the Association for the coming year.

(The motion was seconded and carried.)

PRESIDENT KILLAM. Is there anything further before we start on the committee reports?

In Re DEPARTMENT OF PUBLIC WORKS.

MR. H. V. MACKSEY. I am not sure whether this is the proper time to bring before the Association a matter which came before the Executive Committee and was referred to me by that committee, but possibly it will be just as well to get it out of the way now.

I would say that one of the reasons I am opposed to the Association as an association endorsing good movements in such a way that we might be expected later on to back up our endorsement, is that this one comes before us in that way.

This Association showed its approval and endorsement of a bill introduced in the Senate of the United States to create a Department of Public Works. It is a long bill, about four or five pages, so that I will not attempt to read it to you now, but will simply say to you that the idea is this: that at the present time the public works of the United States are managed piecemeal by various departments, and a very large proportion of the engineering works of the country, which are built mainly to assist in the peaceable pursuits of the people, are in charge of the Army and Navy. It has been felt by the civil engineers of the country, architects, builders, workers, and others, that that was an improper method of managing our affairs. And a bill has been introduced, that a Department of Public Works be established,

which will take care of the planning and designing of all our civil public works, leaving to the Army and Navy only the military affairs. This Association has been asked to endorse that.

The letter which came to our President from Mr. Langdon Pearse, sanitary engineer of the Sanitary District of Chicago, who is one of the officers of the Engineers', Architects', and Contractors' Conference on National Public Works, which is promoting this scheme, says:

"I am sending you enclosed a report giving the proceedings of the Chicago meeting of the Engineering Council. I trust that this will give you the information to present to your society, so that some action can be taken thereon regarding the support of the bill now before Congress.

"I would suggest that an appropriate motion be made to be sent to Senators and Congressmen of Massachusetts, as well as the other New England states, urging them to support the bill, if that is the sense of the convention.

"I also understand that Mr. Leighton, who is handling the executive work of the conference, is now asking for contributions, but I understand that this will be through the national societies. If you anticipate active support, it might be well if you would write to Mr. M. O. Leighton and get further details, in case you have not already received them."

Now, the idea is simply this, — that they wish the endorsement of this Association as to the general movement, and whether the members of this society are sufficiently posted to be willing to give that endorsement or not I do not know. But if we do give that endorsement, we should give it simply as an endorsement, and not bind this society, directly or by implication, to provide funds to carry it through. It is simply an engineer's problem, and this society, although it is composed largely of civil engineeers, is not a society of engineers. This would be a benefit, of course, to many men who are in public works designing and constructing, who are not engineers, but if they wish to help it they could help it individually, both by their efforts and financially. The principal object is "to educate the people concerning the need of consolidating the vast public enterprises of the nation under one single department, which would be known as The Department of Public Works."

And, therefore, Mr. Chairman, I move that the Chair appoint a committee of three to consider this matter and advise the society of the action it should take in the matter, if any.

(The motion was seconded and carried.)

PRESIDENT KILLAM. I will appoint the committee later. The Secretary has a communication from the "National Drainage Congress," which he will read.

The Secretary read communication from National Drainage Congress as follows:

CHICAGO, ILL., September 24, 1919.

MR. WILLARD KENT, *Secy.*,
NEW ENGLAND WATER WORKS ASSN.,
NARRAGANSETT PIER, R. I.

My dear Sir, — Permit me to advise you that the National Drainage Congress will have its eighth annual meeting at the Planters' Hotel, St. Louis, Mo., November 11, 12 and 13, 1919, and to ask that you give this meeting such publicity among your members as you can, and extend to them an invitation to attend this congress and take part in its deliberations.

We believe the matter is of interest to you and your members, as the National Drainage Congress is concerned with the development of the natural resources of our country and the protection of the public health by preventing and remedying such unfortunate conditions as may be caused by the existence of swamp lands and as may follow the floods of our rivers.

We believe that these matters are of sufficient importance to interest all American citizens, and earnestly request your aid in the matter of publicity and attendance at this Eighth Annual Meeting.

Thanking you for your courtesy, I am

Very truly yours,
NATIONAL DRAINAGE CONGRESS.
By JOHN A. FOX, *Director.*

On motion of Mr. Hugh McLean, duly seconded, the communication was received and placed on file.

REPORTS OF COMMITTEES.

Collection and Standardization of Rainfall and Run-off Measurements.

(William T. Barnes, Chairman.)

The Committee to Consider Collection and Standardization of Rainfall and Run-off Measurements submitted its report, as follows:

Boston, Mass., September 22, 1919.

New England Water Works Association,
715 Tremont Temple,
Boston, Mass.

Gentlemen, — Your committee appointed to "Consider Collection and Standardization of Rainfall and Run-off Measurements, particularly in New England," beg to report:

Three meetings have been held, — one jointly with the Boston Society of Civil Engineers' Committee on Run-off.

As a result of the joint conference, your committee conclude that it should confine its work to watersheds, the yield from which would be of interest from the water-works standpoint, leaving data bearing more particularly upon water-power developments for the consideration of and publication by the committee appointed by the Boston Society of Civil Engineers.

Accordingly your committee has taken steps to —

1. Collect, with the intent to publish, rainfall and run-off data which have been reported by various water-works operators but not hitherto published in form accessible to the membership of this Association;
2. Stimulate operators having facilities for obtaining such records but who have not heretofore done so, to begin recording the available data in form suitable for its publication;
3. Publish references to such data as are regularly published in reports readily accessible to the membership and thus avoid duplication of record;
4. Bring down to date the valuable rainfall records presented to this Association in 1913 by Mr. X. H. Goodnough.

With this end in view, your committee has communicated with numerous water-works operators, requesting that they compile these data in form similar to that recorded in the report of Committee on "Yields of Drainage Areas" as recorded in Vol. XXVIII, pages 397–555, 1914, and send to your committee for publication in the Journal.

It is, therefore, to be hoped that in some future issues of the Journal the following data will be published:

1. Rainfall data, 1914–1918, inclusive, for all of the recording stations included in the able paper presented by Mr. X. H. Goodnough in December, 1913, thus making available long-time records of rainfall from stations well scattered over New England and eastern New York, with records brought down nearly to date.
2. Run-off data on streams utilized primarily for water-works purposes, —
   (*a*) Data covering from 1912–1918 in continuation of the data so well presented by the 1912 Committee on "Yield of Drainage Areas";
   (*b*) Similar data not heretofore published, to be arranged in form substantially the same as in the report of the earlier committee.

Your committee would urge all members who may have records of flow of streams to submit their data to your committee, setting it up, if possible, substantially in the same form as was used by the 1912 Committee and recorded in Vol. XXVIII, page 397.

To those who have never recorded the run-off and rainfall in systematic form, we would urge the beginning of such records, that the records may be made available by publishing in the JOURNAL from time to time.

We would also urge the judicious placing of additional rain gages on watersheds under the care of local observers, postal-card reports being sent to the superintendent monthly.

Respectfully submitted,

WILLIAM T. BARNES.

On motion, duly seconded, it was voted that the report be received and the committee continued.

A National Water Law.

(Caleb M. Saville, Chairman.)

The Committee on a National Water Law submitted its report through Mr. Caleb M. Saville, chairman, as follows:

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Your Committee on a National Water Law respectfully submits the following report of progress:

On account of war activities, it has been impracticable for the members of the committee to meet and discuss this matter as frequently as desirable, or to attend meetings of other bodies considering the same subject.

Individual members, however, have interested themselves so far as possible and to some considerable extent. It is now possible for the matter to be taken up and given the attention which it deserves.

We are impressed with the difficulties which beset a local society in gathering data concerning a national question. We are advised that the Water Conservation Committee of the Engineering Council also has this matter under consideration. Realizing that that body, through its extended membership and affiliated associations, is probably the best equipped to make substantial progress, and also realizing that much more can be accomplished by concentration of effort through one representative body, we respectfully recommend that your committee be continued and further authorized to take up the matter with the Water Conservation Committee of the Engineering Council and report progress from time to time to this Association.

Respectfully submitted,

CALEB M. SAVILLE, *Chairman of Committee.*

OCTOBER 1, 1919.

On motion, duly seconded, it was voted that the report be received, the recommendations adopted, and the committee continued.

Report on Power Test Codes of the American Society of Mechanical Engineers.

(Caleb M. Saville, Chairman.)

The committee to represent the New England Water Works Association at the public hearings of the American Society of Mechanical Engineers for the discussion of Power Test Codes of that society, reported as follows:

To the New England Water Works Association:

At the invitation of the American Society of Mechanical Engineers, the New England Water Works Association designated the writer to represent the Association at the meetings of the committee appointed to revise the power test codes of the American Society of Mechanical Engineers.

Several meetings have been held, and substantial progress has been made. This matter is now well in the hands of a very competent committee of twenty-eight, of which Mr. Frederick R. Low is chairman. This committee has on it representatives from various technical societies particularly interested in power development and transmission, and its work is now carried on with vigor.

Attached to and made a part of this report is a bulletin* giving the personnel of the individual committees and the prospectus of the work. Request has been made of the chairman that these bulletins be sent hereafter to the Secretary of the New England Water Works Association so that this Association may be informed of the doings of the committee.

Respectfully submitted,

Caleb M. Saville.

October 1, 1919.

On motion, duly seconded, it was voted to accept the report.

Uniform Accounting.

(Albert L. Sawyer, Chairman.)

Haverhill, Mass., September 27, 1919.

To the New England Water Works Association:

Gentlemen, — In behalf of the Committee on Uniform Accounting I beg leave to submit the following:

This committee has been unable to get together since last January, and therefore has made no progress on the subject assigned it since that time. I would recommend that the committee be re-arranged either with all new members or with a new chairman.

One thing that has handicapped us is the fact that the members are not near

* Filed at office of N. E. W. W. Assn.

enough together to arrange meetings, and we have not seemed to be all together at any of the monthly meetings.

Both Mr. MacKenzie and Mr. Hathaway have, I think, considerable data on the subject.

Personally, I do not seem to have the time necessary to put into this work and should appreciate it if I might be relieved of membership, or at least, if the committee be retained, that another member be made chairman.

It is now three years since the committee was originally appointed, and as so little has been done, I think that if the convention thinks that the subject is of sufficient importance to go on with, they will decide that a new committee might expedite matters, and if not a new committee at least a shake-up in the present arrangement.

Regretting that I have nothing better to offer,

Very respectfully,

ALBERT L. SAWYER, *Chairman.*

Committee:
ALBETT L. SAWYER.
SAMUEL H. MACKENZIE.
ALFRED R. HATHAWAY.
EDWIN L. PRIDE.

On motion of Mr. R. J. Thomas, duly seconded, it was voted that the communication be received and the committee continued.

MR. HUGH MCLEAN. Mr. President, I would like to ask the gentleman who made that motion what his reason is for continuing the committee. Now is the time to change those things. If a man has resigned, what is the object in not letting him resign? Do you know of any information that has not been imparted to this body, so that we can vote intelligently? I do not know how to vote on it.

MR. R. J. THOMAS. My reason for making the motion that the committee be continued is that I know that these men are well qualified for this work. We all know that it has been difficult to get men together during the last two or three years. I think Mr. Sawyer and Mr. Hathaway, and the other members of the committee, are very well versed in that matter, and ought to be given another opportunity. The work of the committees for the last year or two has been greatly hampered, and I think if we continue this committee a little longer we can get results. That was the only object I had in making that motion.

PRESIDENT KILLAM. Perhaps it would be well for the President to make a statement right here. I think one of the hardest things

that the President has to do is the appointing of committees. If you appoint men in a certain section where they can get together at committee meetings, sometimes it looks as though it was a clique; if you appoint them from various districts, it is impossible many times for them to get together and report. Now, the President this year, during the last three or four months, since we got down to a working basis, has attempted to prod all these committees. And perhaps that is the reason why some of them are asking to be relieved.

Personally, I know that this committee has invaluable information, if they will only get together and compile it, but the local conditions have been such that they have not been able to give their time to it. I appreciate it very much. But still we would like to clear up the calendar, and I am in hopes that the calendar will be cleared up before the end of this year on these special committees.

And so, no matter who is your President, do not criticize the committee appointments, until you know his reasons for making them. Sometimes it is advisable to appoint a local committee where they can get together and clear up a subject promptly; at other times it is advisable to appoint a committee, the same as this one, from various sections, who have the information and who in time will give it to us, which will be invaluable when it is compiled. I can say that about this committee because I did not appoint it; it was appointed before I assumed the chair.

Standard Specifications for Water Meters.

(Charles W. Sherman, Chairman.)

Progress report of the Committee on Standard Specifications for Water Meters was read by Charles W. Sherman, chairman, as follows:

To the New England Water Works Association:

During the disturbed conditions resulting from the war, it has not seemed wise for your committee to take any steps in the direction of preparing standard specifications for water meters. Since the conclusion of the war some preliminary work has been done.

The committee has not held a meeting, but some correspondence has been carried on and one of the members of the committee has had conferences with

a representative of the meter manufacturers. We are advised that the manufacturers have been discussing the question of standards and that some progress has been made in this direction. It is probable that within a short time sufficient progress will have been accomplished so that it may be desirable for the manufacturers and your committee to discuss the matter in joint session, after which it will probably be possible to prepare at least a preliminary draft of a meter specification which can be submitted to the Association for discussion.

The committee, therefore, reports progress and hopes to be able to submit a second progress report containing matter for discussion at the next annual meeting of the Association.

Respectfully submitted for the committee,

CHARLES W. SHERMAN, *Chairman.*

SEPTEMBER 30, 1919.

On motion, duly seconded, it was voted that the progress report of the committee be received and the committee continued.

President Killam stated that the Committee on Leakage of Pipe Joints hoped to be able to make a report before the close of the convention.

Adjourned.

AFTERNOON SESSION.

President Killam in the chair.

Mr. Theodore Horton, chief engineer, New York State Department of Health, read a paper entitled, "The Supervision of Public Water Supplies by the New York State Department of Health."

The paper was discussed by Messrs. William P. Mason, Frank L. Fuller, R. W. Sherman, L. M. Hastings, Frank A. Barbour, Caleb M. Saville, F. W. Green, Dow R. Gwinn, and Bertram Brewer.

Dr. William P. Mason, professor of chemistry, Rensselaer Polytechnic Institute, Troy, N. Y., gave a talk on "Swimming Pool Management."

The subject was discussed by Mr. Arthur L. Crane.

Adjourned.

EVENING SESSION.

President Killam presiding.

The Secretary read the names of the following applicants for membership, all of whom had been approved by the Executive Committee, and they were duly elected:

Active: Harry A. Burnham, Newtonville, Mass., fire protection engineer; William B. McCaleb, Philadelphia, Pa., general superintendent, Water Companies, Pennsylvania R. R. — 2.

Associate: Badger Meter Manufacturing Co., Milwaukee, Wis. — 1.

PRESIDENT KILLAM. For the committee on the bill now before the United States Senate, establishing the Department of Public Works, I will appoint Henry V. Macksey, Caleb Mills Saville, and Charles W. Sherman; for the Nominating Committee I will appoint the following past-presidents: Robert J. Thomas, Frank A. McInnes, Robert C. P. Coggeshall, William F. Sullivan, and George W. Batchelder.

Is there anything further to be brought before the Association?

MR. CALEB M. SAVILLE. There is one thing I want to speak of before the business meeting. The President this morning gave what we all thought was a very fine address, which seemed to be well received, and you gave him a vote of thanks, which seemed to me to be rather an empty honor, after all, because you did not do what he asked you to do.

He had several very excellent suggestions in his address, and I think that we would better consider some of them and see if we do not want to do something with them. Two of them, I think, are that a committee of three be appointed to study the finances of the Association and report on a budget system for 1920, on or before the December meeting, and that a committee of three be appointed to make a study of the constitution and by-laws of the Association, to ascertain if there are any changes that it seems desirable to make.

Now, Mr. President, I should like to make a motion that those committees be appointed by the President.

(The motion was seconded and carried.)

Mr. J. Waldo Smith, chief engineer, Board of Water Supply, New York City, read a paper on "Schoharie Development of the New York Water Supply."

Mr. William T. Barnes read a paper entitled, "The Ten-Million-Gallon Covered Reservoir of the Dayton Water Works," prepared by Leonard Metcalf and William T. Barnes, consulting engineers, Boston.

In connection with this subject Mr. Frank L. Fuller, of Wellesley,

Mass., told of the 1 600 000 gal. covered reservoir, flat slab, which was constructed for the town of Webster, Mass., in 1914. Mr. Caleb M. Saville and Mr. Morris Knowles also took part in the discussion.

Adjourned.

WEDNESDAY, OCTOBER 1, 1919.

Under the auspices of the Water Works Manufacturers Association, a steamer was chartered for a day's trip on the Hudson River. The morning and afternoon business sessions were conducted aboard the boat.

MORNING SESSION.

President Killam in the chair.

Mr. Charles W. Sherman, consulting engineer, Boston, read a paper entitled, "Protecting Iron and Steel Standpipes from Corrosion."

The discussion was participated in by Messrs. Frank L. Fuller, Rudolph Hering, Francis T. Kemble, Frank A. Barbour, Lewis M. Bancroft, A. P. Folwell, J. M. Diven, John Cullen, H. T. Gidley, S. E. Killam, E. M. Nichols, J. F. Sullivan, T. R. Kendall, and Frank J. Gifford.

At this point Vice-President H. V. Macksey took the chair.

Mr. Bertram Brewer, assistant engineer, State Department of Health, Boston, read a paper on "Public Control over New Streets, in Relation to Extension of Water Mains."

Messrs. F. J. Gifford, David A. Heffernan, J. M. Diven, T. J. Carmody, W. A. MacKenzie, George A. Stacy, M. N. Baker, Beekman C. Little, Caleb M. Saville, and Francis F. Longley participated in the discussion.

MR. SAVILLE. I should like to make a motion that a committee be designated by the President to consider, collect data, and report with recommendations on the matter of assessments of the cost of main pipe extensions, and the relation of new street layouts in connection therewith, this report to be submitted not later than the next annual convention.

MR. FRANCIS F. LONGLEY. It seems to me that in proposing

a motion of this sort, such as Mr. Saville has proposed, for the consideration of this question, it would be well to include therein a proposal for the consideration also of coöperation that might be secured on the part of real estate men, of the architectural profession, in order to well round out the question.

Mr. J. F. Sullivan. Inasmuch as this is a very interesting subject and the discussion has not been completed on it, I move that this matter of the resolution be laid on the table until the discussion of Mr. Brewer's paper is completed.

(Mr. Sullivan's motion was duly seconded and carried.)

Adjourned.

Afternoon Session.

President Killam presiding.

Col. Francis F. Longley, consulting engineer, New York City, gave a talk on "Water Supplies for the American Expeditionary Forces."

In the absence of Mr. Frank A. McInnes, chairman of the Committee on Grading Water Works with Reference to Fire Protection, Mr. Henry V. Macksey, a member of the committee, read a progress report, as follows:

The Committee on Grading Water Works with Reference to Their Value for Fire Protection.

A revised standard schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions was issued by the National Board of Fire Underwriters in December, 1916. The changes from the preliminary schedule prepared in 1915 and submitted as an appendix to the report of this committee on September 15, 1916, are comparatively slight; the only important ones with regard to the grading of water works are Sections, 21, 31, and 32.

Section 21, as printed at the top of page 31 in our former report, is now changed to read as follows:

21. Small mains in the distribution system:
    (*a*) For per cent. of 4-in. or smaller mains supplying hydrants: Use $\frac{1}{2}$ Deficiency Scale.

(*b*) Add 1 point for each mile of 4-in. or smaller pipe. Do not include areas in which block fronts have less than one fifth the lots built upon, or which are separated from the main system by a natural barrier or considerable open space, nor in larger cities areas outside a 5-mile radius of the district considered.

Reduce the points of deficiency 5 per cent. for each 10 lb. average normal static pressure above 20 lb. if the fire department response throughout the city is such that at least one half the companies are engine companies, otherwise for each 10-lb. pressure above 60 lb. Normal static pressure to be assumed as that carried normally at time of fire. Where there are marked differences in pressure due to topography or separate services, both the above may apply, and the average reduction made.

Sections 31 and 32, as printed at bottom of page 34 and at top of page 35 in our former report, are changed to read as follows:

31 and 32. Size and Installation of Hydrants. — Hydrants shall be able to deliver 600 gal. per minute, with a loss of not more than 2½ lb. in the hydrant and a total loss of not more than 5 lb. between the street main and outlet; they shall not have less than two 2½-in. outlets and also a large suction connection where engine service is necessary. They shall be of such design that when the hydrant barrel is broken off the hydrant will remain closed. Street connection shall not be less than 6 in. in diameter and shall be gated. Hose threads on outlets should conform to the National Standard. Flush hydrants, requiring chucks to be screwed on, are considered undesirable, especially in sections of the country subject to heavy snowstorms, because of delay in getting in operation. Cisterns are considered as of improper type.

31. Hydrants too small or of improper type; to include all with 4-in. connection to main, or with small barrel or foot valve, except those hydrants with large suction outlet in cities using engines and with static pressure of at least 60 lb.; also to include all with single 2½-in. outlet, and all flush hydrants requiring chuck to be screwed on or where covers over hydrant barrel or operating nut of controlling gate are liable to be frozen in or covered by heavy snowfall, except that flush hydrants, with an adequate number of chucks provided having more than one 2½-in. outlet, are to be considered on basis of ½ deficient. If in the high value district considered, there are more hydrants than are required for proper spacing, and the small hydrants are not generally used by the fire department, use in determining the deficiency only the number of small hydrants required to make up the total number necessary for proper distribution; i. e., do not charge for the surplus small hydrants.

(*a*) Use $\frac{1}{5}$ Deficiency Scale for those in high value districts.
(*b*) And add $\frac{1}{5}$ Deficiency Scale for those elsewhere.
Reduce points of deficiency for (*b*) 5 per cent. for each 10 per cent. of 4-in. and smaller pipe charged for under Item 21.

In these changes a concession has been made to the opinion of the committee as expressed in their first report. It will be noted that the method of computing deficiencies for 4-in. pipe has been slightly modified; that when such deficiency has once been charged on account of small size of pipe but little additional deficiency is computed on account of small hydrants on this pipe.

It is obviously the intention of the instructions issued for computing deficiencies to penalize the ordinary commercial 4-in. hydrant under all conditions, but your committee is still of the opinion that this hydrant should not suffer under certain conditions such as when located in an outlying isolated section of a community, or in any location where a discharge not exceeding 500 gal. per minute could be reasonably required.

We are satisfied that a hydrant with 4-in. foot valve can be designed, in fact has been designed, to meet the requirements of the Standard Schedule, and we are therefore decidedly of the opinion that a hydrant capable of delivering two fire streams of 250 gal. per minute each with a loss not exceeding $2\frac{1}{2}$ lb. should be recognized in its proper place.

The other principal point raised by the committee was the danger of crippling the system by the breakage of too frequent or unduly large fire pipe connections. Your committee is still of the opinion that such conditions should be penalized.

The committee wishes to present to the underwriters a more complete record of the disastrous effects of such connections than it now has in its possession and would request our members to forward to the committee all records which they may have of damage resulting from waste and excessive use of water through fire pipe connections.

We are advised by Mr. George W. Booth, chief engineer, that the National Board of Underwriters was unable during the war period to give much attention to the application of the schedule on account of being so fully occupied with government fire protection matters, but it has recently taken it up again, and is actively

engaged in applying it throughout the country. It has up to date made final gradings on about 225 cities. The schedule has been adopted for use by the insurance organizations having jurisdiction in the greater part of the country, including the Southeast, the whole of the Middle West, and New England; the New York State Association is now considering its adoption.

With regard to experiences in New England, Mr. John H. Caldwell, engineer of the N. E. Insurance Exchange, writes us as follows:

"Some time during the last year the Exchange adopted this schedule in connection with the adoption of a standard mercantile schedule which is eventually to supplant the various schedules now in use throughout New England.

"Our first work in connection with the Grading Schedule was the tentative application in approximately twenty-eight cities and towns throughout Massachusetts, ranging from the second to tenth classes. On completion of this work, test applications of the Building Schedule were made, all of which was preliminary work in preparation of the final application of the schedule.

"This summer work was finally started in the city of Cambridge on the application of the schedule for final rating, and this work in that locality is now nearing completion but no rates have been published as yet based on the Grading Schedule and the new mercantile schedule.

"In order that you may be familiar with the results obtained by the application of the Grading Schedule, I am giving you the list of cities and towns [page 376] where we have applied same, with the total number of points of deficiency for all items considered in the schedule, the class of the city, and the total points of deficiency under the item of water works, which I think is the one which you are most vitally interested in."

The committee in its first report stated that it was satisfied that the Standard Schedule was a long step in the right direction, but that until results of its application to water-works systems with which the members are familiar have been made known, criticisms of the details of the schedule were not of controlling significance. As stated in Mr. Caldwell's letter, the application has now been made to a sufficient number of New England cities and warrants study of the details. This must obviously be done by men entirely familiar with the systems to which the schedule is applied. It would be extremely helpful to the committee if the superintendents

of the systems which have been graded would examine the details of the grading and report to this committee any criticism or comment which they may have to make upon its application and the fairness of the results.

MASSACHUSETTS.

City or Town.	Water Works Deficiency.	Total Deficiency.	Class.
Attleboro	6 29	2586	6th
Ayer	1 032	3 535	8th
Belchertown	1 700	4 486	9th
Bridgewater	1 098	3 572	8th
Brookline	341	1 493	3d
Cambridge	505	1 919	4th
Chelsea	141	1 696	4th
Dedham	827	2 833	6th
Gardner	485	2 587	6th
Great Barrington	815	3 018	7th
Haverhill	471	2 084	5th
Holyoke	164	1 248	3d
Housatonic	1 029	3 743	8th
Lawrence	356	1 928	4th
Lowell	178	1 586	4th
Lynn	287	1 528	4th
Melrose	390	2 122	5th
New Bedford	56	1 309	3d
Newburyport	626	3 417	7th
North Adams	436	2 619	6th
Norwood	635	2 718	6th
Pittsfield	308	2 183	5th
Plymouth	662	2 599	6th
Salisbury Beach	1 101	3 586	8th
Somerville	277	1 637	4th
Springfield	95	999	2d
Swampscott	341	2 197	5th
Waltham	451	2 027	5th
Woburn	513	2 289	5th
Worcester	54	1 298	3d

Mr. Booth says, "I think we are safe in saying that the reception of the schedule by the insurance organizations and city officials generally has been very satisfactory and that it has brought about a better understanding of the various fire protection features involved than has been possible heretofore."

While some water-works managers may feel that deficiencies charged against their departments are great, the low rating given may be used to advantage when appealing for appropriations to extend or improve the system under their charge.

For the committee,

FRANK A. MCINNES,
Chairman.

MR. MACKSEY. Now, gentlemen, the only comment I personally have to make upon that is the fact that the representative of the underwriters, Mr. Booth, thinks that we, in the cities, are all very well satisfied. Perhaps when you read over the classification you are given you may feel satisfied. In the city of Woburn I feel sure the people will not feel satisfied, because they have been led to believe that they were in Class 3, and by doing certain things would come into Class 2, and here we find we are in Class 5. And we intend to get a copy of our grading and go through it point by point and see what we can do to improve our conditions and to claim what we believe to be fair treatment from the underwriters.

Now, of course you all understand that the underwriter's idea is perfection at other people's expense — particularly at other people's expense. No matter what we do, they will ask for something better. That is not such an awful thing after all, because it will keep us trying to do better; we shall never be perfect but we will keep doing better.

In regard to the 4-in. fire hydrant, I think I speak for a number of men who deal with small cities and towns and where it would be foolish to spend our money on hydrants with 5- or 6-in. valves, when we could have a greater number of hydrants with 4-in. valves more advantageously placed and where they could do greater service for our cities and towns. We intend to stick to and defend the 4-in. hydrant until they show us that that is not so. [*Applause.*]

On motion, duly seconded, it was voted that the report of progress be accepted and the committee continued.

Adjourned.

Evening Session.

President Killam in the chair.

The Secretary read the following list of applicants for membership, approved by the Executive Committee, and they were duly elected:

Active: James Bedell, Ossining, N. Y.; Floyd A. Nagler, Albany, N. Y., hydraulic engineer.

Mr. H. S. R. McCurdy, engineer Miami Conservancy District, Englewood, Ohio, read a paper entitled, "Hydraulic Fill Dams of the Miami Conservancy District."

Mr. Frank L. Fuller, Mr. Robert E. Horton, Mr. Stephen H. Taylor, Mr. Morris Knowles, and Mr. G. Edward Gilson took part in the discussion.

Mr. Norman J. Howard, bacteriologist in charge, Toronto Filtration Plant, Toronto, Ont., read a paper on "The Operation of and Purification Effected by the New Drifting Sand Filter System at Toronto."

Messrs. Howard W. Green, G. A. Sampson, James M. Caird, Theodore Horton, M. N. Baker, W. C. Hawley, William J. Orchard, Paul Lanham, Morris Knowles, F. F. Longley, and Charles W. Sherman took part in the discussion.

Adjourned.

Morning Session, Thursday, October 2, 1919.

President Killam presiding.

This session was made a superintendents' experience meeting, and was opened by Mr. David A. Hefferman, superintendent Water Works, Milton, Mass., who chose as his subject, "Damages to Hydrants by Motor Vehicles, Their Repairs and Preventives."

The matter of trouble with paint coming off the inside of pipe and the re-painting of the pipe was also discussed, as well as the relative merits of various pipe linings.

The discussion on these subjects was participated in by Messrs. S. H. MacKenzie, Frank J. Gifford, H. T. Gidley, George A. King, W. A. MacKenzie, Francis H. Luce, Dow R. Gwinn, Frank L. Fuller, Stephen H. Taylor, John Cullen, Charles W. Sherman,

Samuel E. Killam, William R. Conard, W. C. Hawley, Edward D. Eldredge, and George A. Benjamin.

The motion of Mr. Caleb M. Saville, which was laid on the table at the morning session of October 1, 1919, that a committee be appointed by the President to consider, collect data, and report with recommendations on the matter of assessment of the cost of main pipe extensions and the relation of new street layout in connection therewith, this report to be submitted not later than the next annual convention, was taken from the table, and after discussion the motion was carried.

Adjourned.

Afternoon Session.

Under the auspices and through the courtesy of the Rensselaer Polytechnic Institute at Troy, N. Y., a visit was made to their new swimming pool, and luncheon was served at the Institute. After the luncheon President Killam introduced Hon. Cornelius F. Burns, mayor of Troy, who spoke as follows:

Ladies and Gentlemen, — I did not know that I was to be called upon, but it makes no difference to Trojans when they are called upon, as they are always ready to perform the duty that is assigned to them.

It is always a pleasure to have people come into our municipality. Our only regret is that the elements are such that we are unable to carry out the program which we had outlined for the day. This is our day for the inspection of our municipal departments, and I had arranged to have a band here and take you down two blocks and have you look over one of the greatest departments in the state of New York — that is, we always make that claim, and we think we are justified in it. However, we can't do it, and I expect it is due in great measure because you people are in the water-works business, and therefore I presume God is with you and He is sending the rain so that when you go back home there won't be any question about having the reservoirs full. And that is the only way you will get full under the present laws of the country. [*Laughter.*]

However, I can assure you it is my great pleasure to be with you

to-day in this short space of time and extend to you a cordial and hearty greeting on behalf of the people of Troy, and we only hope that it will be but a short time when we may be honored by having you with us again, but I assure you that I will not be in office when you come. However, I will be here just the same. I thank you very much. [*Applause.*]

PRESIDENT KILLAM. I thank you, Mr. Mayor. We greatly appreciate all that has been done for us here in Troy. Only a day or two ago Dr. Mason said that we should have come to Troy instead of Albany for our headquarters. Perhaps Dr. Mason knew better than we did, but he should have advised us earlier in the year.

We are very grateful to Dr. Mason for all that he has done for us. To Mr. Caldwell, who is also chairman of the Manufacturers Committee of Arrangements, vice-president of the R. P. I., and president of no end of concerns in Troy and other places, we extend our heartfelt thanks for all that he has done for us to make our visit to Albany and Troy one round of pleasure.

To Dr. Ricketts, who has been called away to the city, I would say that everything I have ever seen about this institution, from the time we entered the gates until we sat down to what they call a luncheon, has been efficiency, — efficiency first, last, and always; and if this is a luncheon I should like a real good dinner here sometime. [*Applause.*]

I understand that the autos are nearly ready and I will call upon Mr. Patrick Gear to lead us in three cheers.

(Under the leadership of Mr. Gear three rousing cheers were given for the mayor of Troy, three cheers for the City of Troy, and three for Mr. Caldwell.)

After the luncheon, through the courtesy of the Water Department of the city of Troy, a motor trip was made over the Troy watershed. The return to Troy was by way of the State Barge Canal, at which time operation of the locks was demonstrated for the benefit of the members of the Association.

Morning Session, Friday, October 3, 1919.

President Killam in the chair.

The Secretary read the following list of applicants for membership, approved by the Executive Committee, and they were duly elected:

Thomas E. Lawler, Poughkeepsie, N. Y., consulting engineer; B. E. Fox, West Springfield, Mass., clerk water department; J. Frank Whiting, West Springfield, Mass., superintendent water department. — 3.

Mr. Paul Lanham, engineer in charge of waste detection, Washington, D. C., read a paper on "Detection of Losses from Underground Piping Systéms."

The discussion was participated in by Messrs. Frank L. Fuller, Dow R. Gwinn, George H. Abbott, S. H. MacKenzie, W. C. Hawley, E. G. Reynolds, A. P. Folwell, and D. A. Heffernan.

Mr. Robert E. Horton, consulting engineer, Voorheesville, N. Y., read a paper entitled, "Watershed Leakage."

Messrs. W. A. MacKenzie, L. M. Hastings, Lincoln Van Gilder, and Charles W. Sherman took part in the discussion.

President Killam. I will take this opportunity to appoint the following committees: Constitution and By-Laws, H. V. Macksey, F. J. Gifford, and R. J. Newsom; Budget, George A. Carpenter, Frank A. Marston, and Edwin L. Pride; Extension of Mains, Caleb M. Saville, W. C. Hawley, and Bertram Brewer.

Adjourned.

Afternoon Session.

President Killam presiding.

The President read the applications for membership, approved by the Executive Committee, of the following persons, and they were duly elected.

Arthur T. Clark, Herkimer, N. Y., superintendent and engineer Municipal Commission; Paul Lanham, Washington, D. C., waste prevention engineer.

Mr. Frederic E. Beck, chief engineer, Consolidated Water Company, Utica, N. Y., read a paper on "Experience in Metering Fire Services."

Messrs. Frank L. Fuller, J. M. Diven, G. H. Abbott, Robert E. Horton, Dow R. Gwinn, Paul Lanham, Lincoln Van Gilder, Charles W. Sherman, W. C. Hawley, Harry H. Burnham, Samuel E. Killam, H. T. Gidley, William F. Sullivan, A. E. Martin, and Edward D. Eldredge took part in the discussion.

A paper entitled, "Dangerous Reduction to Insulation Resistance in High-Pressure Fire-Service Motors Due to Moisture," by William W. Brush, deputy chief engineer, Department of Water Supply, Gas, and Electricity, New York City, was read, in the absence of Mr. Brush, by Mr. Charles W. Sherman.

It was suggested by Mr. Harry Gardner (editor *Engineering World*) that a paper on this subject was read at the last convention of the American Institute of Electrical Engineers — not particularly relating to motors on pumps but motors in general, and suggesting methods for overcoming the difficulty.

Invitation for 1920 Convention.

President Killam. I have here two telegrams sent from Springfield in regard to the next annual convention. The first one reads as follows:

> In behalf of the citizens of Springfield, wish to extend cordial invitation to hold next meeting in our city.
>
> Arthur A. Adams, *Mayor.*

The second one reads:

> We want you in 1920. Let us welcome you to our city.
>
> Wm. H. Shuart,
> *President Chamber of Commerce.*

These will naturally be referred to the next Executive Committee.

Adjourned.

Evening Session.

President Killam in the chair.

The Secretary read the application for membership, approved by the Executive Committee, of Stephen Bond Story, civil engineer, Rochester, N. Y.

On motion of Mr. Charles W. Sherman, the Secretary was instructed to cast the ballot of the Association in favor of the applicant named, and he having done so the applicant was declared a duly elected member of the Association.

PRESIDENT KILLAM. Is there anything further to come before the Association?

MR. CHARLES W. SHERMAN. I wish we had one of our real orators of the Association here, to say the words that ought to be said in recognition of the many courtesies which have been extended to this Association during this convention. I can't remember when a convention has seemed to be more enjoyable. Although I have not attended all of them, I have attended the greater part of them for the last twenty-five years. This has not been the largest convention we have ever had; I do not know that it has been the best, but it has been one of the best, and certainly it has been extremely enjoyable from every point of view.

We have been indebted to a great many persons, organizations, corporations, and I don't know what else for courtesies of all kinds, and they have helped to make our stay pleasant and enjoyable. We owe them a great deal more than our thanks, but all we can really give them is our thanks, which I am sure we do most heartily.

In order that it may be on our records, I formally move that the thanks of the New England Water Works Association be extended to the City of Albany, the City of Troy, the Rensselaer Polytechnic Institute, the Chambers of Commerce of Albany and Troy, the Water Works Manufacturers Association, the Municipal Gas Company and the Ten Eyck Hotel, for all they have done to make the convention now closing so successful and enjoyable.

I hope I have not omitted in this list any one of the larger organizations. There are, of course, many individuals whom it is impracticable to attempt to mention by name.

(The motion was seconded and unanimously adopted by a rising vote.)

Mr. D. A. Decrow, manager Water Works Department, Worthington Pump and Machinery Corporation, New York City, read a paper entitled, "Tests of the Unaflow Pumping Engine."

Messrs. Harry Gardner, A. P. Folwell, William F. Sullivan, Edward D. Eldredge, and Charles W. Sherman took part in the discussion.

Mr. W. P. Mosteller, U. S. Iron Pipe and Foundry Company, Philadelphia, Pa., gave a talk on the "Test of Bell and Spigot Joint for Gas Pipe at Twenty-five Pounds Pressure."

The discussion was participated in by Messrs. Edward D. Eldredge, Charles W. Sherman, Harry Gardner, Samuel E. Killam, R. L. Hall, William F. Sullivan, and George H. Abbott.

PRESIDENT KILLAM. Is there anything further to be brought before the Association? [*No response.*]

We are now closing what seems to me to be a very interesting and instructive convention, — one, I think, which we have all enjoyed, both from a business point of view and through the entertainments which have been furnished us. We have endeavored to work while we worked and play while we played. And, as far as I know, every one has enjoyed himself, with one exception. That was on the first day, when we gave out the medal. That medal entirely disappeared during the session from the floor of the convention. I am pleased to say to-night that I have the medal in my pocket. [*Applause.*] How I got that medal I am not at liberty to say, because I have no proof where it went to; all I can do is to turn it over to the man to whom it belongs. It has worried me considerably to think that anything like that could happen in a convention of the New England Water Works Association, and I trust it never will happen again.

A motion to adjourn is in order.

MR. CHARLES W. SHERMAN. I move the convention now adjourn.

(The motion was duly seconded and carried.)

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at Pemberton, Mass., Wednesday, June 25, 1919.

Present: President Samuel E. Killam, Henry V. Macksey, Frank A. Barbour, James H. Mendell, Frank J. Gifford, Henry A. Symonds, and Willard Kent.

Nine applications for membership were received and by unanimous vote recommended therefor, viz.: Bernhard Hoffman, Stockbridge Water Company, Stockbridge, Mass.; J. M. Jones, superintendent Bristol and Warren Water Works, Bristol, Conn.; A. Maxwell McKenzie, assistant engineer Water Works, Wallingford, Conn.; Ernest L. H. Meyer, superintendent Water Department and city engineer, Glens Falls, N. Y.; Charles B. Hayward, president Fire and Water Engineering, Inc., New York, N. Y.; William J. Orchard, civil engineer, New York, N. Y.; Theodore Reed Kendall, engineering editor *The American City*, New York, N. Y.; John H. Lance, consulting engineer, Wilkes-Barre, Pa.; Kenneth Q. Volk, civil engineer, Los Angeles, Cal.

Voted: That a meeting of the Executive Committee be held at the call of the President to confer with a committee of the Manufacturers Association in regard to constructive program of entertainments for the next annual convention.

Adjourned.

Attest,

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Friday, August 1, 1919, pursuant to call issued by the President.

Present: President Samuel E. Killam and members Charles

W. Sherman, Percy R. Sanders, Frank A. Barbour, Patrick Gear, Lewis M. Bancroft, Willard Kent, and, by invitation, Frank A. McInnes and T. C. Clifford, Burt B. Hodgman and John A. Kienle of the Water Works Manufacturers Association.

After discussion, on motion of Mr. Barbour, seconded by Mr. Gear, it was voted: That pending approval of this policy for future conventions by the Association as a whole, the exhibit and entertainment features at the Albany convention be delegated to the Manufacturers Association, it being understood that no manufacturer not a member of the New England Water Works Association shall be permitted to exhibit, that a New England section of the Manufacturers Association shall be formed, and that associate members of the New England Water Works Association shall be invited to join this local section, or — if exhibitors without membership — shall pay a reasonable charge for the privilege of exhibiting, and that badges of active members and of guests of active members shall be paid for by the New England Water Works Association and distributed by the Secretary of the Association.

Adjourned.

Attest,

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., on Wednesday, September 17, at 2 o'clock P.M.

Present: President Samuel E. Killam and members James H. Mendell, Frank J. Gifford, Patrick Gear, Lewis M. Bancroft, and Willard Kent.

Four applications for membership were presented, viz., Charles R. Barker, N. E. Insurance Exchange, 141 Milk Street, Boston, Mass.; John S. Caldwell, N. E. Insurance Exchange, 141 Milk Street, Boston, Mass.; John A. McKone, president, Board of Water Commissioners, Hartford, Conn.; and Samuel A. Sewell, superintendent, St. John Water and Sewerage Department, St. John, N. B.; and the applicants were by unanimous vote recommended therefor.

The report of "Committee on Award of the Dexter Brackett Memorial Medal," — Messrs. William T. Barnes, William F. Sullivan, and George W. Batchelder,— recommending the award for the year 1918 to Mr. David A. Heffernan, superintendent Milton Water Works, Milton, Mass., for his paper entitled, "Practical Methods for Detecting Leaks in Underground Pipes," was received, and it was unanimously voted: That the award of the Dexter Brackett Memorial Medal for the year 1918 be, and hereby is, made to Mr. David A. Heffernan.

The President announced the death of Mr. John Mayo, superintendent of the Bridgewater Water Works, a member of this Association, and on motion of Mr. Gifford seconded by Mr. Bancroft, Messrs. Horace Kingman, Alvin C. Howes, and D. N. Tower were appointed a committee to prepare a memoir.

A communication from the Roosevelt Memorial Association asking for endorsement and assistance in their work was referred to the Convention of the Association for action.

The President appointed as a committee on accommodations for the winter meetings of the Association, Messrs. Frank J. Gifford, Charles W. Sherman, and Frank A. Barbour.

Adjourned.

Attest,

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at the Ten Eyck Hotel, Albany, N. Y., September 30, 1919.

Present: President Samuel E. Killam, Henry V. Macksey, Charles W. Sherman, Patrick Gear, Lewis M. Bancroft, and Willard Kent.

Twenty applications for active membership and two for Associate membership were received and recommended therefor, viz.:

Members: Charles R. Barker, engineer Municipal Protection Dept., N. E. Insurance Exchange, Boston, Mass.; James Bedell, Municipal Bldg., Ossining, N. Y.; H. A. Burnham, Newtonville, Mass.; John S. Caldwell, engineer, N. E. Insurance Exchange, Bos-

ton, Mass.; Arthur T. Clark, superintendent and engineer, Municipal Commissioners, Herkimer, N. Y.; Francis W. Collins, consulting engineer, New York, N. Y.; B. E. Fox, clerk Water Dept., West Springfield, Mass.; Irving H. Henderson, foreman, Cambridge Meter Dept., Cambridge, Mass.; John F. Laboon, of Chester & Fleming, consulting engineers, Pittsburgh, Pa.; Paul Lanham, water survey engineer, Bryant Street Pumping Station, Washington, D. C.; Thomas F. Lawlor, president, Board of Public Works, Poughkeepsie, N. Y.; Francis C. Millspaugh, hydraulic engineer, Lowell, Mass.; William B. McCaleb, general superintendent, Water Companies, Philadelphia, Pa.; John A. McKone, president, Board of Water Commissioners, Hartford, Conn.; Floyd A. Nagler, civil engineer, Albany, N. Y.; Eliot B. Norton, superintendent, Cambridge Water Works Co., Cambridge, N. Y.; Francis J. Seery, professor hydraulic engineering, Cornell University, Ithaca, N. Y.; Samuel A. Sewell, superintendent St. John Water and Sewerage Dept., St. John, N. B.; Stephen B. Story, civil engineer, Rochester, N. Y.; J. Frank Whitney, superintendent Water Dept., West Springfield, Mass.

Associates: Badger Meter Mfg. Co., Milwaukee, Wis.; Flower Valve Mfg. Co., Detroit, Mich.

Three applications for reinstatement were received, and it was unanimously voted that the applicants be and hereby are reinstated to associate membership on complying with the requirements of the Constitution.

Attest,

WILLARD KENT, *Secretary.*

WILLARD KENT, *Sec'y*,

715 Tremont Temple, Boston, Mass.

$ .75
Dear Sir: Enclosed please find 1.50 in payment of charge for Certificate
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of Membership in the N. E. W. W. Association ($1.50), and Membership Button ($ .75), which please mail me and oblige

Yours truly,

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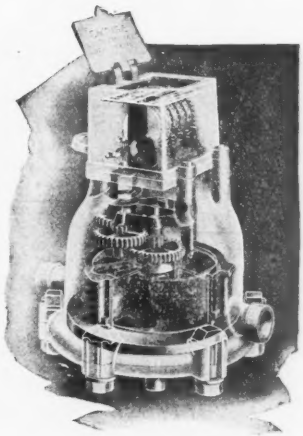

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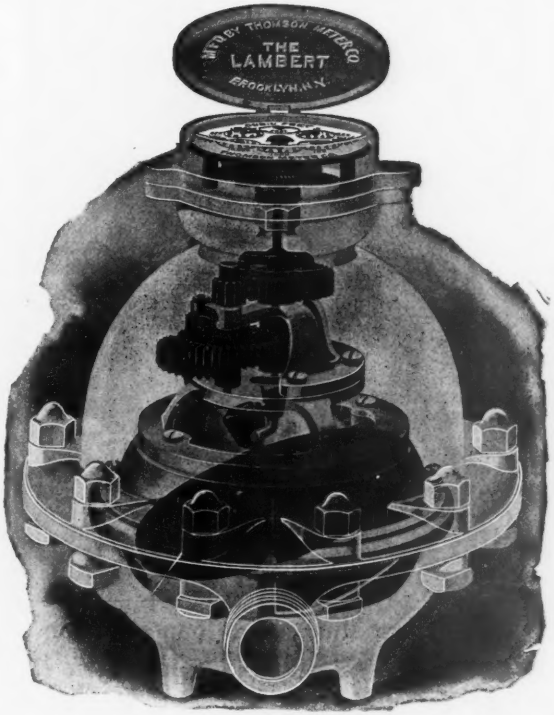

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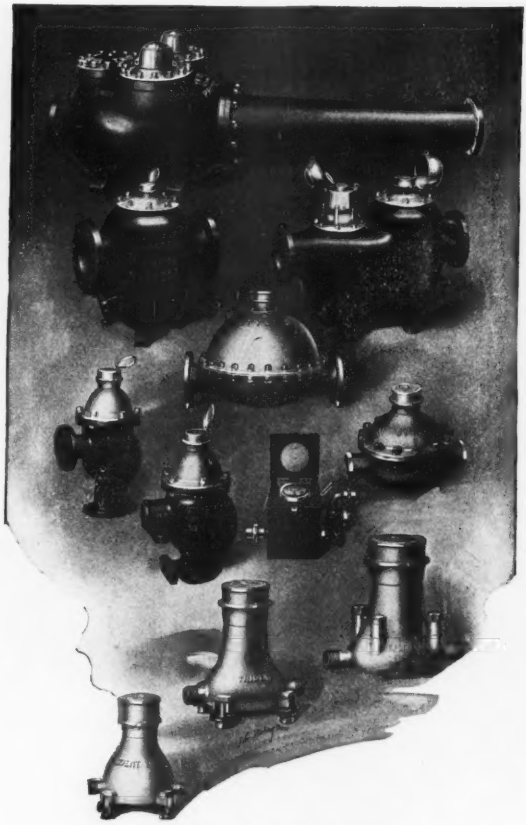

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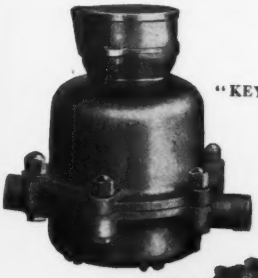

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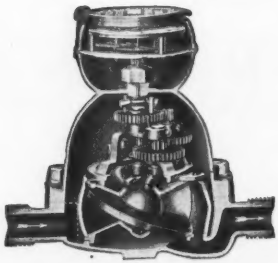

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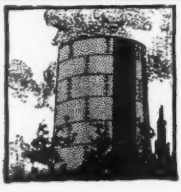

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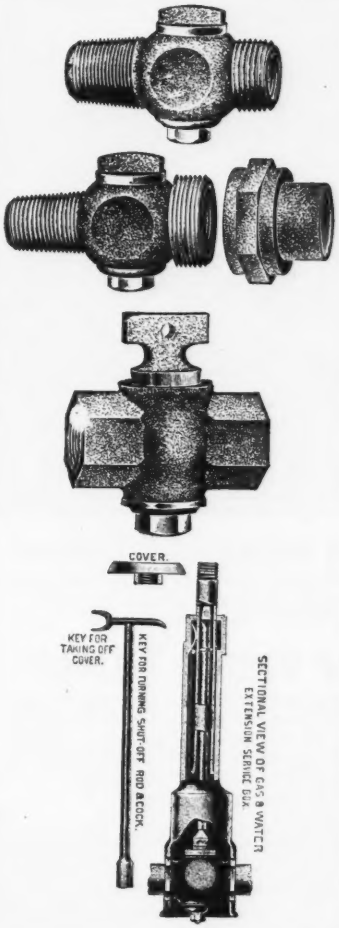

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Let us send at our risk, on 30 days' trial, a

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which is recognized to be the most easily operated owing to the few working parts.

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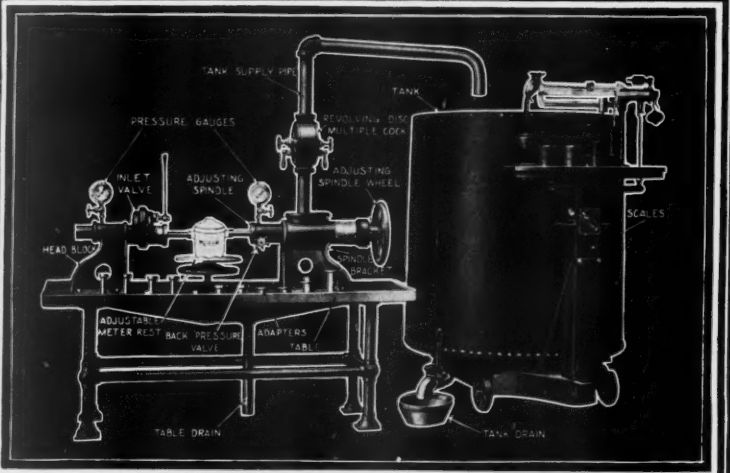

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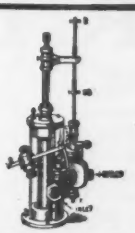

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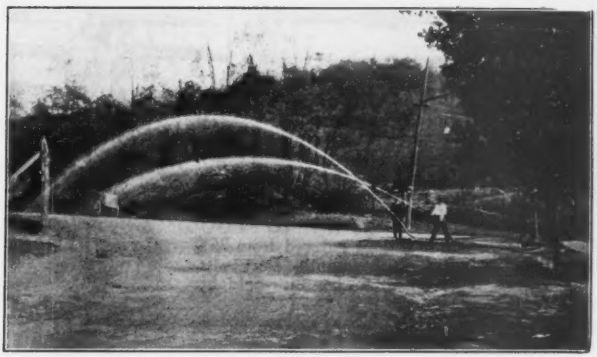

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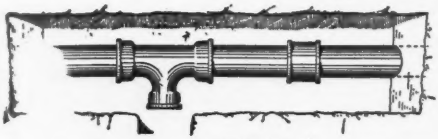
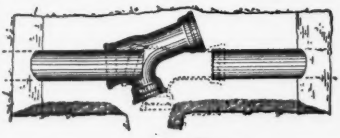
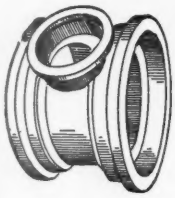


Old Way



Our Way



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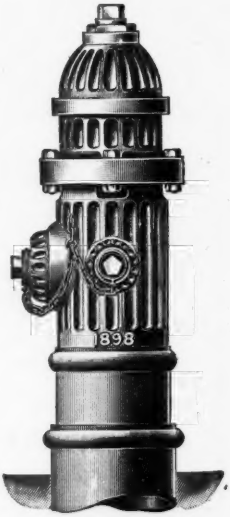

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A half century of use has established their reputation as being the most economical, durable and simple hydrant.

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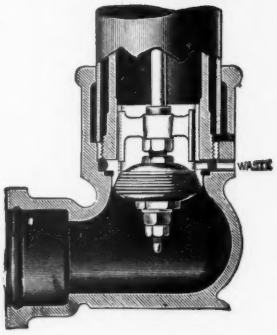

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ANTI-FRICTION
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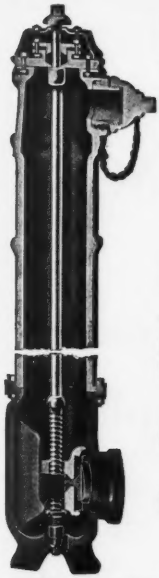

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This hydrant is anti-freezing, because when the drainage is good no water is left in it to freeze.

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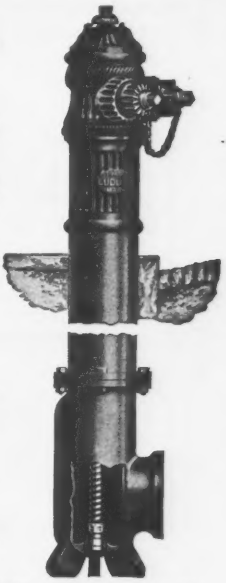

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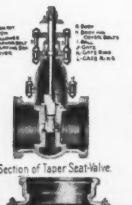
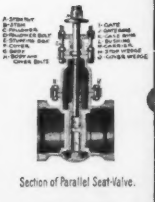


Hydrant with Independent Nozzle Cut-off.

Section of Taper Seat-Valve.



Section of Parallel Seat-Valve.

Section of Vertical Check-Valve.

Section of Vertical Foot-Valve.

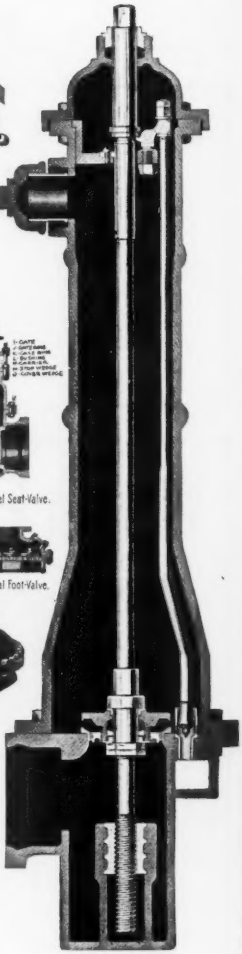
Horizontal Check-Valve.

Vertical Foot-Valve.

Hydrant with Water Crane Attachment.

Indicator Post.

Water Crane with Automatic Drip Valve.



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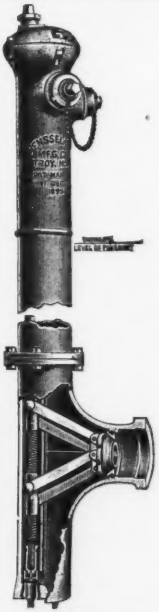

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should be of interest to you, if you use the

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Such is the latest story of Cast-Iron Pipe efficiency — and the efficiency of the good, old-fashioned bell-and-spigot joint.

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Also **Pure Block-Tin Lined Iron Pipe and Fittings**

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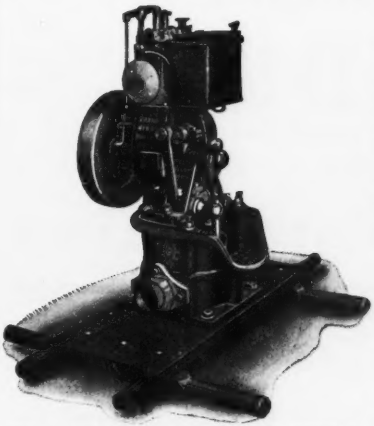

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Can be attached to any Diaphragm Pump

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Mounted on Skid or 4-Wheel Hand Truck, as desired.

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YOU SHOULD USE

Trade "LEADITE" Mark

Registered U. S. Patent Office

FOR

Jointing Water Mains

1. **DURABILITY.** Leadite joints increase in strength with age.
2. **NO CAULKING.** Leadite joints require no caulking, because the Leadite adheres to the pipe, making a water-tight bond.
3. **COMPARATIVE QUANTITIES.** One ton of Leadite is equivalent to four tons of lead.
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5. **COST.** Its use saves 50 to 65 per cent. over lead, owing to the saving effected in material and labor.
6. **TOOLS.** As no caulking is required, fewer tools are needed.
7. **TRANSPORTATION.** Considerable freight charges are saved because Leadite is lighter than lead.
8. **HAULING.** Saves hauling expense on the work because you move only one fourth the weight of jointing material.
9. **FUEL.** Saves fuel because you melt only one ton of material instead of four, and not as much heat is required either.
10. **DELIVERY.** We can make prompt shipments.
11. **DAMAGE SUITS.** Claims for damages caused by joints blowing out are prevented because Leadite joints will not blow out under any pressure.
12. **USERS.** Progressive water works all over the country use Leadite.

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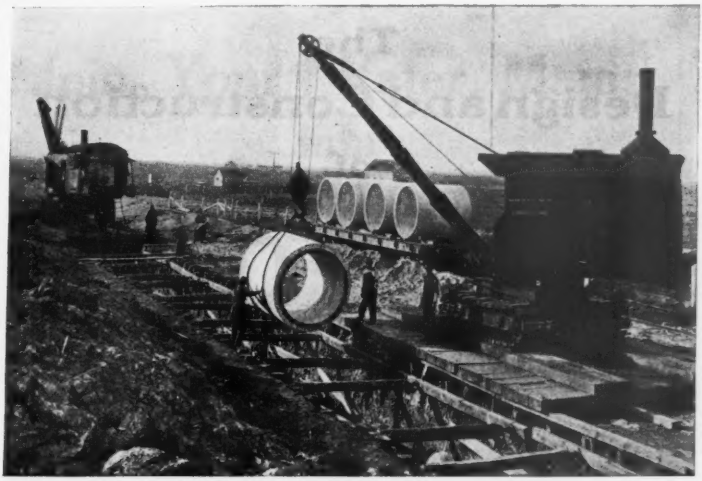

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All Pressure Pipes are provided with Copper Expansion Joints.

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AND CUT YOUR EXPENSES

50% FIRST COST

50% SMALLER BELL HOLES

75% HANDLING

100% CALKING

OUR PROPOSAL

That the prospective users purchase a trial lot of 1 to 5 bags, and that this be used under the direction and according to the instructions of our representative.

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Michigan Pipe Co. . . . . Back cover

New England Water Works Association,

ORGANIZED JUNE 12 1882.

APPLICATION FOR MEMBERSHIP.

I, the undersigned, residing at.....

.....*being desirous of admission into the New England Water Works Association, hereby make application for* .....
(resident, non-resident or associate)

.....*membership.*

I am.....*years of age, and I have been engaged in the following named work:*

.....

.....

.....

I will conform to the requirements of membership if elected.

Signed,.....

Address,.....

Dated,.....*191*

Resident members are those residing in New England; all others are non-resident.
Entrance fee is $5.00 for resident and $3.00 for non-resident members.
Annual dues are $4.00 for both resident and non-resident members.

Patronize

the Advertisers in the

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